FSIS Risk Assessment for Guiding Public Health-Based Poultry Slaughter Inspection

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U.S. Department of Agriculture

August 2012

United States Department of Agriculture
Food Safety and Inspection Service

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EXECUTIVE SUMMARY

Background

The Food Safety and Inspection Service is proposing a new inspection system to change allocation of inspection personnel in poultry slaughter establishments. Under new inspection system guidelines, individual poultry slaughter establishments will decide whether to operate under a slightly modified version of the current inspection system (9 CFR § 381.76) or the proposed new system.

The intent of the proposed new inspection system is to allow FSIS resources to be used more efficiently. If this efficiency reduces the occurrence of foodborne pathogens such as *Salmonella* and *Campylobacter* on finished poultry products, then a net public health benefit may result. Improved efficiency should occur by allowing more time and flexibility for FSIS personnel to perform off-line verification activities based on human health risk factors specific to individual establishments. The proposed new system may also drive technological innovation by the industry because they will have greater control over carcass sorting and establishing maximum line speeds.

FSIS on-line inspectors currently conduct hands-on appraisals of every poultry carcass to ensure it is unadulterated, free of feathers, bruises, and defects and disease, while FSIS off-line inspectors verify that establishments maintain sanitary operations and perform other health- and safety-related assignments. Many of the on-line inspection tasks are related to food quality rather than food safety.

This risk assessment updates a 2008 risk assessment, originally presented in conjunction with a review by the National Advisory Committee on Meat and Poultry Inspection (NACMPI, 1,3), with new data and a modified modeling approach. This version of the risk assessment takes into consideration public and stakeholder comments [Docket No. FSIS-2011-0012].

The original risk management questions were:

Risk Management Questions

Can FSIS reallocate inspection activities in young chicken slaughter establishments without significant negative impact on microbial prevalence in the establishments?

How will the relocation of on-line inspectors to off-line duties, or other areas within or outside the establishment, affect human illness?

Where within the establishment can relocated inspection activities have the most impact toward reducing microbial prevalence and corresponding human illness?

What is the uncertainty about these effects?

Structure and Scope

This is a quantitative food safety risk assessment. It examines the relationships between variations in personnel assignments and inspection activities in FSIS poultry slaughter facilities compared to the prevalence of both *Salmonella* and *Campylobacter* on young chicken and young turkey and, subsequently, attributable human illness.

Logistic regression analysis is performed to estimate the relationship between off-line inspection procedures and contamination of carcasses with either *Salmonella* or *Campylobacter.* A stochastic simulation model uses the estimates from the logistic regression to forecast the effect of changes in off-line inspection *categories* on changes in human *Salmonella* or *Campylobacter* illnesses attributable to the consumption of young chicken and young turkey. The simulation model incorporates uncertainty about the regression coefficients, uncertainty about the expected change in off-line inspection activities with the new inspection system, and uncertainty in the current estimate of human illnesses, into its forecasts about the change in human illnesses that could occur as a result of implementation of the new inspection system.

Data used in the risk assessment came from several sources. Inspection activities data from FSIS's PBIS database were paired with *Salmonella* and *Campylobacter* prevalence data for the same establishments and timeframes:

> Young chicken data comprise results of the FSIS Young Chicken Baseline study (July 2007 through September 2008, 8) and PR/HACCP *Salmonella* verification program (July 2007 through September 2010).
> Young turkey data comprise results of the FSIS "Young Turkey Baseline" (August 2008 through July 2009, 9) and PR/HACCP *Salmonella* verification program (July 2007 through September 2010).

Estimates for the mean number of human *Salmonella* and human *Campylobacter* illness attributable to young chicken and turkey consumption were based on distribution parameters estimated from total foodborne illness and outbreak data from Centers for Disease Control and Prevention (1, 10, 12).

Change scenarios predict how prevalence of both *Salmonella* and *Campylobacter* and ultimately annual human illnesses might change based on 4 categories of decision variables (scheduled-and-performed procedures [SP], unscheduled procedures [U], scheduled-not-performed procedures [SNP], and non compliances [NC]). As Agency guidance has heretofore been unspecific about the types of offline inspection procedures that could improve from the new inspection system, an "indiscriminate" scenario is propagated in which all 4 categories of decision variables are randomly changed. Uncertainty distributions for each of these change decision variables is developed using information provided in the FSIS HIMP report (13). *We assume that off-line inspection activities after the voluntary implementation of the new inspection system will parallel off-line inspection activities in current HIMP establishments.*

Model Results

Indiscriminate scenario: These results describe estimated changes in both poultry slaughter establishment prevalence and in attributable human illnesses associated with an indiscriminate change across all 4 decision variables – based on the premise that unspecified changes (increases in terms of procedures performed, decreases in terms of unperformed procedures and non-compliances) might occur across all off-line inspection activities.

Discriminating scenario where unscheduled procedures are targeted for increase: These results describe estimated changes in both poultry slaughter establishment prevalence and in attributable human illnesses associated with a targeted increase in unscheduled inspection procedures while holding other decision variables constant – based on the observation that in HIMP establishments up to 60% more unscheduled procedures are performed than in non-HIMP establishments. Given that more unscheduled procedures are a likely focus the new inspection system, this specific scenario is of interest.

Predicted annual changes in *Salmonella* and *Campylobacter* prevalence in chicken establishments: When off-line procedures are indiscriminately changed in young chicken establishments, the analysis predicts an average decline of 2 percent (mean) (.005, .04) (10th and 90th percentile, respectively) in the percentage of positive *Salmonella* samples. The analysis also predicts that there could be a small increase -.0002(-.018, .007) in the percentage of positive *Campylobacter* samples. This could be due to the effect that non compliances – a poorly understood explanatory variable in this model, have on the predicted estimates for *Campylobacter.*

If only unscheduled inspection procedures in young chicken slaughter establishments are targeted for increase the analysis predicts a average decline of 2 percent (mean) (.008, .038) in the percentage of positive *Salmonella* samples. The analysis also predicts that there is a small decline .005(-0, .017) in the percentage of positive *Campylobacter* samples.

Predicted annual changes in human illnesses attributable to chicken establishments:
There is an 87 percent probability that human illnesses will decline if all off-line inspection procedures are changed ‘indiscriminately’ (as described above) in young chicken slaughter establishments. *Salmonella* illnesses are expected to decline by an average of 4,203 (mean) (872, 8,089) (10th and 90th percentile, respectively), while *Campylobacter* illnesses could increase by 462 (-2,668, 1,067). However, the modes of these distributions indicate a decline of 3,181 *Salmonella* illnesses and 0 *Campylobacter* illnesses from young chicken.
If only unscheduled inspection procedures in young chicken slaughter establishments are targeted for increase, there is a near 100 percent probability that human illnesses will decline. *Salmonella* illnesses are expected to decline by an average of 4,044 (1,390, 7,301), while *Campylobacter* illnesses could decrease by 868 (0, 2,728). Similarly, the modes of these

distributions show declines of 2,483 *Salmonella* illnesses and 0 *Campylobacter* illnesses related to increases in unscheduled procedures.

Predicted annual changes in *Salmonella* and *Campylobacter* prevalence in turkey establishments: When off-line procedures are indiscriminately changed in young turkey establishments, the analysis predicts an average decline of 4 percent (-.02, .11) in the percentage of positive *Salmonella* samples. The analysis also predicts that there could be a decrease of 17 percent (-.015, .32) in the percentage of positive *Campylobacter* samples.

If only unscheduled inspection procedures in young turkey slaughter establishments are targeted for increase the analysis predicts a average decline of 3 percent (-.004, .08) in the percentage of positive *Salmonella* samples. The analysis also predicts a similar decline of 17 percent (.021, 32) in the percentage of positive *Campylobacter* samples.

Predicted annual changes in human illnesses attributable to turkey establishments:
There is also an 87 percent probability that human illnesses will decline if all off-line inspection procedures are changed indiscriminately in young turkey slaughter establishments. *Salmonella* illnesses are expected to decline by an average of 311 (-146, 834), while *Campylobacter* illnesses are expected to decline by 119 (9, 252). The decline in the mode of 161 *Salmonella* illnesses and 0 *Campylobacter* illnesses from young turkey is expected.

If only unscheduled inspection procedures in young turkey slaughter establishments are targeted for increase, there is a 94 percent probability that human illnesses will decline. *Salmonella* illnesses are expected to decline by an average of 242 (-30, 603), while *Campylobacter* illnesses could decrease by 118 (12, 249). The distribution modes indicate a decline of 90 *Salmonella* illnesses and 0 *Campylobacter* illnesses related to increased unscheduled procedures in young turkey establishments.

Conclusions

The risk assessment provides answers to each of the four risk management questions.

Can FSIS reallocate inspection activities in young chicken slaughter establishments without significant negative impact on microbial prevalence in the establishments?

In general, the probability that indiscriminate changes in off-line inspection procedures will increase the annual rate of human illnesses is small, and there is a greater probability that such changes would contribute to no net change or even reductions in human illnesses. Nevertheless, this analysis suggests ambiguous effects of the proposed rule with respect to *Campylobacter* occurrence on chicken carcasses. The larger probability of increased *Campylobacter* illnesses from contaminated chicken carcasses is primarily driven, however, by the non-compliances decision variable. This decision variable is poorly understood and the intended effect of changes in this category of procedures is arguable. The frequency of non-compliance reports could decrease either because plant performance improves or because incidents of non-compliance are less frequently detected and reported. It is noteworthy that removing the effect of this decision variable in alternative scenarios substantially reduces the probability that the human illness rate might increase.

This latter conclusion is further supported by consideration of the HIMP structural variable in the chicken-*Campylobacter* regression model (see Appendix). That model suggests that participation in HIMP was associated with a reduced prevalence of *Campylobacter*. Although *Campylobacter* occurrence was not considered in an analysis of HIMP establishments (13), these regression findings suggest that the positive *Salmonella* implications of that HIMP analysis also apply to *Campylobacter*. While not a focus of this risk assessment, the regression model's implication about HIMP establishments should provide some measure of confidence about the effects of the proposed rule – which intends to replicate HIMP across a wider swath of the poultry industry.

How will the relocation of on-line inspectors to off-line duties, or other areas within or outside the establishment, affect human illness?

Most likely point estimates from a scenario that indiscriminately changes all four decision variables in our analysis suggest a net reduction (mode) of 3,342 *Salmonella* illnesses attributable to both young chicken and young turkey establishments. This analysis assumes that the total annual *Salmonella* illnesses rate attributed to poultry is centered about 174,686 (1). Therefore, the proposed rule might be expected to prevent 1.9% of these illnesses per year.

Most likely point estimates from the same scenario suggest that there will be no net change in the annual rate of *Campylobacter* illnesses in either chicken or turkey establishments.

Where within the establishment can relocated inspection activities have the most impact toward reducing microbial prevalence and corresponding human illness?

The most reliable implication from the regression models is that increasing unscheduled procedures seems to reduce pathogen occurrence on carcasses. The other decision variables suggest ambiguous effects from their intended changes when those effects are considered across all four pathogen-product models.

What is the uncertainty about these effects?

Our modeling approach includes uncertainty about regression coefficients that relate the frequency of inspection activities to pathogen prevalence, uncertainty about the change in future inspection activities, and uncertainty in the baseline annual rates of human Salmonella and Campylobacter illness attributable to poultry. These sources of uncertainty translate into substantial uncertainty about forecasted changes in illness rates.

This analysis necessarily focuses on the "down-side" potential of the proposed rule, i.e., the probability that proposed changes to inspection may cause illness rates might increase. This focus seems appropriate for a proposed rule that intends to change inspection processes in slaughter establishments. Significantly, however, the uncertainty about changes in illness rates includes "up-side" potential that illnesses avoided could be substantially larger than the model values cited.

The uncertainty that surrounds these forecasts suggests monitoring opportunities for FSIS following implementation of the proposed rule. For example, FSIS can periodically assess aggregate inspection procedures and compare these to the baseline predictions from this model. Such comparisons will empirically measure the changes occurring for the decision variables in the model and reduce the current uncertainty about these model inputs. Also, under the proposed rule, FSIS will continue to monitor the pathogen prevalence on carcasses among participating and non-participating establishments. The pathogen verification testing data can be used to assess correspondence with its expectations following implementation of the proposed rule.

INTRODUCTION

FSIS is proposing a system to change allocation of inspection personnel in poultry slaughter establishments. Under the proposed rule, poultry slaughter establishments will decide whether to operate under a modified traditional inspection system (9 CFR § 381.76) or the proposed new system.
The intent of the proposed new inspection is to allow FSIS resources to be used more efficiently and to lead to industry innovations in operations and processing. Improved efficiency should occur by allowing more time and flexibility for FSIS personnel to perform off-line verification activities based on risk factors specific to individual establishments. The proposed new system may also drive technological innovation by the industry because they will have greater control over carcass sorting and establishing maximum line speeds. It is anticipated that greater control by industry will encourage slaughter establishments to adopt new procedures, equipment, and processing techniques. Consequently, the industry will be responsible for designing its own process control tasks, which will incorporate new and improved procedures, equipment, and processes as appropriate. This should result in the efficient production of poultry products. If the proposed rule reduces the occurrence of foodborne pathogens such as *Salmonella* and *Campylobacter* on finished poultry products, then a net public health benefit may result.

This risk assessment updates a 2008 risk assessment (2), originally presented in conjunction with a review by the National Advisory Committee on Meat and Poultry Inspection (NACMPI) (3), with new data and a modified modeling approach. This version of the risk assessment takes into consideration public and stakeholder comments [Docket No. FSIS-2011-0012].

The original risk management questions were:

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- How will the relocation of on-line inspectors to off-line duties, or other areas within or outside the establishment, affect human illness?
- Where within the establishment can relocated inspection activities have the most impact toward reducing microbial prevalence and corresponding human illness?
- What is the uncertainty about these effects?

This updated risk assessment reexamines these questions using a methodology similar to the 2008 risk assessment but augmented with additional data.

METHODS

Logistic regression analysis is performed to estimate the relationship between off-line inspection procedures and contamination of carcasses with either *Salmonella* or *Campylobacter.* A stochastic simulation model uses the coefficient estimates from the logistic regression to forecast the effect of changes in off-line inspection *categories* on changes in human *Salmonella* or *Campylobacter* illnesses attributable to the consumption of young chicken and young turkey. The simulation model incorporates uncertainty about the regression coefficients, the expected change in off-line inspection activities following implementation of the proposed rule, and the current estimate of human illnesses into its forecasts about the change in human illnesses.

Regression model description

An overview of the regression model is provided here. More detail about the regression model can be found in the Appendix to this report.

The model relates occurrences of *Salmonella* and *Campylobacter* among poultry carcasses to four decision variables – each representing a category or grouping of off-line inspection procedures – and several structural variables, which are variables that describe differences in plant design, inspection system and other demographic characteristics. Young chicken data comprise results of the FSIS Young Chicken Baseline study (July 2007 through September 2008) and PR/HACCP *Salmonella* verification program (July 2007 through September 2010). Young turkey data comprise results of the FSIS Young Turkey Baseline study (August 2008 through July 2009) and PR/HACCP *Salmonella* verification program (July 2007 through September 2010).

The four decision variables are Scheduled and Performed procedures (SP), Scheduled and Not Performed procedures (SNP), Unscheduled procedures (U), and Non-Compliances (NC). These four categories serve to group the six Inspection System Procedure (ISP) Codes into mutually exclusive classes. The ISP codes refer to (i) sanitation, (ii) HACCP, (iii) wholesomeness/economic consumer protection, (iv) sampling, (v) sanitation performance standards, and (vi) emergency procedures. Each ISP code is further delineated into more precise activities and most activities are noted as either SP, SNP, U or NC. The four decision variables represent the sum of activities on each establishment day across the various ISP codes as follows:

> SP = scheduled and performed procedures for sanitation(01), HACCP(03), wholesomeness/economic consumer protection(04), sampling(05), other inspection requirements(06), sanitation performance standards (06D01), raw ground (03B), raw not ground (03C), fecals (03J), economic poultry kill (04C04)
>
> SNP = scheduled not performed procedures for sanitation(01), HACCP (03), wholesomeness/economic consumer protection(04), sampling (05), other inspection

requirements (06), sanitation performance standards(06D01), raw ground (03B), raw not ground (03C), fecals(03J), economic poultry kill (04C04)

U = unscheduled procedures performed for sanitation(01), HACCP(03), wholesomeness/economic consumer protection(04), sampling(05), other inspection requirements(06), sanitation performance standards(06D01), raw ground(03B), raw not ground(03C), fecals (03J), economic poultry kill (04C04), emergency procedures (08)

NC = non-compliant procedures for sanitation(01), HACCP(03), wholesomeness/economic consumer protection(04), sampling(05), other inspection requirements(06), sanitation performance standards(06D01), raw ground(03B), raw not ground(03C), fecals(03J), economic poultry kill(04C04)

We chose the four defined categories because the expected/intended effect of the proposed policy was consistent for procedures within each category. For example, the proposed increase in off-line inspectors is expected to increase scheduled and performed procedures. Similarly, increased availability of off-line inspectors should increase unscheduled procedures while reducing scheduled but not performed procedures. We also assume that – in the long-run – reported non-compliances will decrease with more off-line inspectors in slaughter establishments because such establishments will attain appropriate process control through increased inspection scrutiny and also through likely industry innovation. Although we explored an alternative approach that collapsed decision variables according to the six ISP classes of off-line procedures, this approach created confusion about the intended effect of the proposed policy within each class. For example, a random variable that summarized HACCP procedures would need to increase scheduled and performed procedures (and unscheduled procedures) but also decrease scheduled but not performed procedures (and non-compliances).

After considering several alternative sets of decision variables, this treatment of decision variables avoids some potential problems with collinearity in the model. It also avoids over-interpretation of specific procedures that might simply reflect random associations that can occur with over-parameterized models.

Rejected versions of the regression analysis on the extensive dataset included more than 40 decision variables representing specific ISP codes. The analysis of these complicated models was indeterminate because these variables could be correlated with each other. Such collinearity made inferences about specific coefficients potentially invalid. .

Previous versions also attempted to simplify inferences about specific variables by developing submodels that eliminated other variables and isolating the effect of the variable of interest. Nevertheless, predictions from submodels required consideration of the implications across all submodels such that each submodel would be weighted as part of a whole. Such a weighting scheme was deemed too complicated and potentially fraught with error to pursue.

Instead, the current regression approach estimates a single regression equation for each product-pathogen pair (i.e., young chicken-*Salmonella*, young chicken-*Campylobacter*, young turkey-*Salmonella*, and young turkey-*Campylobacter*). This is a valid approach to making predictions from each model. The four decision variables are included in each regression model. For one of these decision variables to be found statistically significant in the model, the totality of its inspection procedures must be strongly associated with pathogen occurrence. Consequently, inferences made about significant variables are stronger, but more general, than inferences from previous models with more decision variables.

Estimates of the decision variables for the four regression models suggest inconsistent effects (Table 1). The proposed rule should result in fewer SNP procedures because more off-line personnel will be available to complete scheduled procedures. Nevertheless, the sign of the coefficient of the significant SNP variable in the turkey-*Salmonella* model suggests that reducing SNP will actually increase *Salmonella* prevalence in turkey. In contrast, the coefficient sign for SNP in the other models (i.e., a positive sign) suggests that decreasing occurrences in this category will decrease pathogen prevalence in these product classes.

All four models support the expectation that increased activity in the U category will reduce pathogen prevalence (i.e., the coefficient sign is negative). The U variable is highly significant in the chicken-*Salmonella* model and the turkey-*Campylobacter* models, but not significant (at a p=0.05 significance level) in the other two models. Nevertheless, the p-value for these other two models does not entirely reject the possibility that the U random variable may be importantly associated with pathogen occurrence.

The only model in which scheduled and performed procedures (SP) are significant decision variables is that for turkey-*Campylobacter*. The other models suggest – although the variables are not statistically significant at the p=0.05 level - that increasing this random variable will increase pathogen prevalence.

Interpreting the direction of intended changes to non-compliance (NC) episodes in establishments is problematic. On the one hand, FSIS expects that increased off-line inspection resources will generate improved process control within establishments that adopt the proposed rule. Improved process control should – in the longer term – result in fewer non-compliance reports from these establishments. On the other hand, these increased off-line inspectors will also be able to identify non-compliant activities and thereby generate more reports (at least in the short term). As these two perspectives imply, reported non-compliances are a function of failures in process control and the availability of inspection personnel to detect these failures. As such, the non-compliance decision variable is different from the other three decision variables because it partly reflects occurrences (i.e., failures) that are not controlled by off-line inspectors. In contrast, the other decision variables are directly amenable to change simply by changing inspection resources (e.g., unscheduled procedures can increase or decrease directly with the number of off-line inspectors – these do not require detection of establishment failures).

Based on analysis of the HACCP Inspection Models Project (HIMP) (13), we assume that fewer non-compliances are intended to occur following implementation of the proposed rule. Nevertheless, the regression model results are inconsistent across the four models. The two models in which the NC variable is statistically significant have opposite signs for this coefficient (i.e., the chicken-*Campylobacter* model suggests prevalence will increase if NC decreases while the turkey-*Salmonella* model suggests the prevalence will decrease if NC decreases). Similarly, in the cases where NC is not significant, the chicken-*Salmonella* model suggests prevalence will decrease while the turkey-*Campylobacter* model suggests it will increase.

Table 1. Decision variable estimates from four regression analyses are shown.

Product-Pathogen	Decision Variable	Coefficient Estimate	Std Error	p-value	Variable Mean	Variable Std Dev
Young chicken – *Salmonella*	SP	0.0021	0.0021	0.1587	12.9624	6.0291
	SNP	0.0461	0.0093	<0.0001*	0.5536	1.0524
	U	-0.0032	0.0009	0.0002*	29.1353	20.5648
	NC	0.0091	0.0096	0.1716	0.7834	1.1422
Young chicken - *Campylobacter*	SP	0.0076	0.0065	0.1212	6.5629	0.8762
	SNP	0.0198	0.0107	0.0321*	0.6929	0.26
	U	-0.0014	0.0011	0.1016	31.0927	7.3283
	NC	-0.0157	0.0074	0.0170*	1.3634	0.3212
Young turkey – *Salmonella*	SP	0.0054	0.0121	0.3277	10.7622	6.3381
	SNP	-0.0805	0.0408	0.0243*	0.4945	1.0889
	U	-0.0208	0.019	0.1368	6.9431	3.1892
	NC	0.0581	0.0223	0.0046*	1.8542	3.6883
Young turkey - *Campylobacter*	SP	-0.0344	0.0203	0.0451*	10.8187	4.2699
	SNP	0.0444	0.0573	0.2192	0.9022	1.3254
	U	-0.1027	0.0303	0.0004*	8.8464	3.1642
	NC	-0.0548	0.0801	0.247	0.5374	1.0612

**Significant difference for two-sided t-test on the regression coefficient*

The mean values for the decision variables indicate the average number of daily instances across the population of all establishments for each category of off-line inspection procedures represented in the data (Table 1). For example, the average number of scheduled and performed procedures used as explanatory variables in the chicken-*Salmonella* model is ~13 per establishment per day. Similarly, the average number of unscheduled procedures is ~29 per establishment per day. Comparing these values with the chicken-*Campylobacter* data suggests similarities (e.g., 31 vs. 29 for U) and differences (e.g., ~7 vs. ~13 for SP). Differences highlight the fact that the dataset for chicken-*Salmonella* is augmented with testing data generated from the PR/HACCP testing while the chicken-*Campylobacter* model only includes data from the Chicken Baseline study. A similar explanation applies to comparisons between the two turkey datasets.

Model to forecast the effect of proposed rule

To address the risk management questions, we develop a method for forecasting the effects of the proposed rule on public health. This method examines the change in pathogen prevalence as predicted by a regression model and mathematically maps the change in prevalence to a change in the annual rate of human illnesses.

A simple prevalence-based risk assessment method was assumed based on Williams et al. (11). The general approach assumes annual illnesses can be modeled as a Poisson process. Therefore, we use the standard notation of the Greek letter lambda (λ) to reflect the rate parameter of a Poisson distribution in the following model description.

We define a model to forecast the effect of the proposed poultry slaughter rule as follows:

$$\lambda_{avoided} = \left(1 - \frac{Prev(policy)}{Prev(baseline)}\right) \times \lambda_{ill}$$

where $\lambda_{avoided}$ is the annual rate of product-pathogen illnesses avoided following policy implementation; λ_{ill} is the current annual rate of product-pathogen illnesses (i.e., before policy implementation); $Prev(policy)$ is the post-chill prevalence of pathogen-contaminated poultry carcasses projected following policy implementation; $Prev(baseline)$ is the post-chill prevalence of pathogen-contaminated poultry carcasses projected prior to policy implementation[1].

The baseline prevalence is defined as $Prev(baseline) = \frac{e^{\alpha+\beta_1 X_1+\ldots+\beta_i X_i+\ldots+\beta_n X_n+\varepsilon}}{1+e^{\alpha+\beta_1 X_1+\ldots+\beta_i X_i+\ldots+\beta_n X_n+\varepsilon}}$, where the variables and coefficients are estimated via the logistic regression models described above.

The prevalence following policy implementation is $Prev(policy) = \frac{e^{\alpha+\beta_1 X_1+\ldots+\beta_i X_i \boldsymbol{A}_i+\ldots+\beta_n X_n+\varepsilon}}{1+e^{\alpha+\beta_1 X_1+\ldots+\beta_i X_i \boldsymbol{A}_i+\ldots+\beta_n X_n+\varepsilon}}$, where one or more of the random variables are adjusted by A_i to account for a change that occurs following policy implementation. Because we want to forecast post-chill prevalence, the rehang structural random variable in the regression model is adjusted to reflect post-chill testing (i.e., its value is set to one) when estimating both $Prev(baseline)$ and $Prev(policy)$.

The inputs λ_{ill}, $Prev(baseline)$, $Prev(policy)$ and A_i are all uncertain variables in this assessment. To assess the uncertainty about $\lambda_{avoided}$, a Monte Carlo model[2] was developed to

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[1] Note that $\lambda_{avoided}$ might be negative if $Prev(policy) > Prev(baseline)$. In such cases, the negative sign would reflect an increase in that rate parameter (although the negative sign would not directly enter a Poisson distribution).

[2] All Monte Carlo simulations were completed using Palisade's @Risk software in Microsoft Excel. Each simulation comprises 100,000 iterations; this number of iterations was deemed to produce sufficiently stable forecasts.

propagate these sources of uncertainty to a forecast about the annual rate of illnesses avoided. In this model, uncertainty about regression coefficients[3] was modeled as $\beta_i \sim Normal\left(\hat{\beta}_i, stderror(\hat{\beta}_i)\right)$; uncertainty about A_i was modeled as $A_i \sim Pert(min, mode, max)$; uncertainty about λ_{ill} was modeled as $\lambda_{ill} \sim \log normal\left(\mu, \sigma\right)$. Because $\lambda_{avoided}$ is a function of the ratio of *Prev(policy)* and *Prev(baseline)* - and these random variables can be reasonably assumed to be correlated – each iteration of a simulation paired the estimates of *Prev(policy)* and *Prev(baseline)* such that each estimate reflected the same uncertain coefficient values from the regression model.

Estimates of λ_{ill} are needed for all four product-pathogen pairs. We model uncertainty about the total *Salmonella* and *Campylobacter* illnesses per year attributable to young chickens and young turkeys by considering the uncertainty in the total annual domestically acquired foodborne illnesses estimated by CDC (Scallan et al., 2011, 12). The mean estimated total cases (and 90% credibility interval) for *Salmonella* and *Campylobacter* were 1,027,561 (644,786 – 1,679,667) and 845,024 (337,031 – 1,611,083), respectively.

A previous analysis estimated that the fractions of total *Salmonella* and *Campylobacter* illnesses per year attributable to young chicken as 16.33% (167,831/1,027,561) and 19.71% (168,291/845,024), respectively (FSIS, 2011, 1). That analysis also estimated the fraction of total *Salmonella* and *Campylobacter* illnesses per year attributable to young turkeys as 0.67% (6855/1,027,561) and 0.08% (714/845,024), respectively.

These attribution fractions are applied to the credibility intervals of Scallan et al. (12) to determine the 5th and 95th percentiles of a putative lognormal distribution that describes uncertainty about the annual cases of these pathogens attributed to each poultry class (Table 2). Nevertheless, this treatment ignores uncertainty associated with the fraction of illnesses attributed to each poultry class. Consideration of this source of uncertainty awaits further development of this parameter by CDC and other food safety agencies.

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[3] We assume independence in the errors among the independent variables (i.e., we do not include covariance terms between these variables). The calculated standard error from the regression is somewhat smaller than the value as we have simulated it; this result suggests that the aggregate effect of any non-zero covariance terms is to reduce uncertainty in modeled forecasts. Therefore, our simple treatment increases uncertainty and is deemed conservative for that reason.

Table 2. Estimated Number of Annual *Salmonella* and *Campylobacter* Illnesses, with Uncertainty Bounds, from Young Chicken and Turkey.

Product-Pathogen	Estimated attributed annual illnesses[1]			Lognormal distribution parameters[2]	
	Mean	5th percentile	95th percentile	Mu	Sigma
Young chicken - Salmonella	167,831	105,313	274,340	12.043	0.291
Young chicken - Campylobacter	168,291	66,413	317,473	11.886	0.476
Young turkey - Salmonella	6,855	4,320	11,254	8.850	0.291
Young turkey - Campylobacter	714	283	1,353	6.428	0.476

[1] These distribution parameters are estimated from total illness data (12) and attribution fractions for *Salmonella* and *Campylobacter* (1).

2 This parameterization assumes ln(annual illnesses) ~ Normal (Mu, Sigma). The lognormal distribution parameters were estimated using a percentile fitting algorithm:

$$\mu = \frac{\ln(95th\%ile) + \ln(5th\%ile)}{2}, \sigma = \frac{\ln(95th\%ile) - \mu}{Z_{0.95}}$$ where $Z_{0.95}$ is the 95th percentile of a standard Normal distribution. The fitting algorithm obtains a mean of 177,329 for chicken – Salmonella. which is a reasonable approximation of the intended uncertainty distribution.

We also need estimates of the adjustment parameters A_i that reflect the expected change in the decision variables following implementation of the proposed rule. To establish baseline prevalence estimates, we assume each decision variable equals the mean from data used to estimate the regression models. In the policy scenarios, we assume the mean of each random decision variable will be adjusted as follows:

> Scheduled and performed and unscheduled procedures in an establishment could either increase, decrease, or stay the same, once an establishment adopts the new inspection system in the proposed rule. FSIS inspection records in HIMP establishment are considered to be a good indicator of what a new FSIS inspection system might look like under the proposed rule. On average, FSIS inspectors performed 14,136 offline verification inspections per HIMP establishment in CY2010 versus an average of 8,724 offline verification inspections per non-HIMP establishment. This varied from 1.6 times more offline verification inspection procedures in HIMP establishments than in non-HIMP establishments to 3.2 times more HACCP verification inspection procedures (13). Because a fraction of establishments already participate in HIMP and another fraction of establishments will not adjust in response to the proposed rule, we assumed a most likely value of a 25% increase in SP and U procedures in our policy scenario. At a minimum, we assumed no change and we assumed a maximum 60% increase in these procedures. Therefore, for the SP and U decision variables, we model $\boldsymbol{A}_i \sim Pert(1.0,1.25,1.6)$.

Scheduled-but-not performed procedures would most likely decline under the new inspection system, as the primary reason for SNPs in an establishment is limited personnel to complete the offline procedure. Because the new inspection system requires fewer scheduled procedures, it is difficult to compare current HIMP data on SNP procedures. We conservatively assume that these SNP procedures will be reduced by a most likely10%, but could be reduced by 100% or not change at all. Therefore, for the SNP decision variable, we model $\boldsymbol{A}_i \sim Pert(0.0, 0.9, 1.0)$. Note: to test the sensitivity of this assumption we also looked at a minimum value of 0.5 for this change variable, but the results were not significantly altered and we only used the above distribution in the final analysis.

We are uncertain as to how recorded non-compliances might change in establishments under the new FSIS inspection system, for reasons discussed above. Current FSIS inspection records in HIMP establishment are considered a good indication of what a new FSIS inspection system might look like. On average, the current data suggests that HIMP broiler establishments have 26 percent fewer reported health-related non-compliances than do non-HIMP broiler establishments (a simple average reduction across all inspection categories from table 3-6 of the 2011 HIMP report) (13). Nevertheless, non-compliances may be reduced by 100% or not change at all. Therefore, for the NC decision variable, we model $\boldsymbol{A}_i \sim Pert(0.0, 0.74, 1.0)$. In this case we also tested the sensitivity of this assumption , by modeling a minimum value of 0.74, and a most likely value of 0.9 for this change variable, but the results again were not significantly altered and we only used the above distribution in the final analysis.

Implementation scenarios

To forecast how annual illness rates might change following implementation of the proposed rule, we initially assumed that the four decision variables would all change according to the assumptions outlined above. We term this forecast an “indiscriminate” scenario because its adjustments make no further assumptions about how FSIS might emphasize or de-emphasize particular decision variables in the regression models with the new inspection system.

An alternative scenario (Increase U) considers how human illness forecasts might change by emphasizing changes to the unscheduled procedures (U) decision variable while leaving other decision variables unchanged. This alternative scenario is modeled such that the $\boldsymbol{A}_i$ parameter for the U decision variable is the same as explained above while the A_i parameter values for the other decision variables are fixed at a value of one, to indicate no change from the baseline in the other inspection activities. The decision to consider this alternative scenario is based on the consistency of this decision variable’s sign (i.e., negative) across all four product-pathogen models; its statistical significance in one chicken and one turkey model; and the assumption that FSIS will particularly emphasize performance of the equivalent of unscheduled procedures in the new inspection system.

RESULTS

Predicted annual changes in *Salmonella* and *Campylobacter* prevalence in turkey establishments: Table 3 shows that when off-line procedures are indiscriminately changed in young chicken establishments, the analysis predicts a average decline of 4 percent (-.02, .11) in the percentage of positive *Salmonella* samples. The analysis also predicts that there could be a decrease of 17 percent (-.015, .32) in the percentage of positive *Campylobacter* samples.

If only unscheduled inspection procedures in young chicken slaughter establishments are targeted for increase Table 4 sows that the analysis predicts a average decline of 3 percent (-.004, .08) in the percentage of positive *Salmonella* samples. The analysis also predicts a similar decline of 17 percent(.021, 32) in the percentage of positive *Campylobacter* samples.

Table 3. Summary statistics of changes in establishment prevalence from Monte Carlo simulations of the indiscriminate scenario across the four product-pathogen models are shown.

	Change in prevalence mean(10th percentile, 90th percentile)	
	Salmonella	*Campylobacter*
young chicken establishments	.02(.006,.038)	-.002(-.018,.007)
young turkey establishments	.04(-.02,.11)	.17(.015,.32)

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Table 4. Summary statistics of changes in establishment prevelance from Monte Carlo simulations of the unsceduled procedures scenario across the four product-pathogen models are shown.

Unscheduled procedures Scenario	Change in prevalence mean(10th percentile, 90th percentile)	
	Salmonella	*Campylobacter*
young chicken establishments	.02(.008,.038)	.005(-0,.017)
young turkey establishments	.03(-.004,.08)	.17(.015,.32)

Predicted changes in human illness: The results for predicted changes in human illness are graphically summarized in Figures 1-4, depicting the cumulative probability plots for the indiscriminate and alternative scenarios across the four product-pathogen pairs. We first focus on the indiscriminate scenarios.

The analysis indicates that we might expect (with high probability) a small net benefit of decreased illnesses, but that there is a small probability of a net increase. Except for the chicken-*Campylobacter* forecast, the indiscriminate analyses suggest a high probability that the proposed policy might result in a decrease in human illnesses (Table 5). This means there is a 95%, a 37%, an 80%, and a 99% chance that illnesses will not increase for the chicken-*Salmonella*, chicken-*Campylobacter*, turkey-*Salmonella* and turkey-*Campylobacter* models, respectively Stated a different way, the probability that illnesses might increase (i.e., a negative value for illnesses avoided) is 0.05, 0.63, 0.20, 0..01 for the chicken-*Salmonella*, chicken-*Campylobacter*, turkey-*Salmonella* and turkey-*Campylobacter* models, respectively.

Of the measures of central tendency (mean, median and mode), the modal (most likely) value represents the least change from the baseline across the four models in the aggregate (i.e., summing net illness rate changes) (Table 5). This is consistent with the intuition that by themselves, the changes in inspection activities being considered are most likely to have no large effect in either direction. The modes from the indiscriminate scenario suggest a net reduction of 3,342 in the annual rate of *Salmonella* illnesses and no change in the annual rate of *Campylobacter* illnesses.

At best, the chicken-*Campylobacter* model results are ambiguous as to the effect of an indiscriminate implementation of the proposed rule. The forecasted increase in *Campylobacter* illnesses is primarily driven by the SP decision variable and the statistically significant NC decision variable. For both of these variables, the expected changes serve to increase prevalence and their effects tend to overwhelm the prevalence-decreasing effects of expected changes to the SNP and U decision variables.

The simulation results in Table 3 also reflect the aggregate change in total illnesses (i.e., *Salmonella* + *Campylobacter*) across chicken and turkey slaughter industries. To estimate this value, the $\lambda_{avoided}$ values for the chicken-*Salmonella* and chicken-*Campylobacter* models were summed on each iteration of a Monte Carlo simulation. This same approach was used for the turkey models. It should be noted that the adjustments to the U decision variable were the same for both pathogen models (i.e., the draws from the random variable $\boldsymbol{A}_i$ were perfectly correlated between the two chicken models and the two turkey models).

The combined illnesses avoided results suggest the probability that illnesses associated with both young chicken and turkey establishments might increase is ~0.13. This result suggests with approximately 87% confidence that aggregate human illnesses will be unchanged or decrease following an indiscriminate implementation of the proposed poultry rule.

Alternative scenarios considered the effect of only increasing unscheduled procedures (Table 6). In each of these alternative scenarios, the other decision variables were assumed to not change, although uncertainty in their regression coefficients was still included in the simulations.

In the chicken-*Salmonella* model, the alternative scenario suggests a minor reduction in the probability that the *Salmonella* illness rate will increase. Furthermore, the similarity of the uncertainty distributions for the "Increase U" and "Indiscriminate" scenario results suggests the importance of the U decision variable in that indiscriminate scenario (Figure 1).

The alternative scenario in the chicken-*Campylobacter* model suggests a substantial reduction in the probability that the *Campylobacter* illness rate will increase (i.e., from 0.63 to 0.10). This scenario avoids increased illnesses mostly because it does not include the effect of decreasing non-compliances. In fact, this alternative scenario suggests the potential for avoiding substantially more *Campylobacter* illnesses if FSIS emphasizes increased unscheduled procedures – and de-emphasizes reducing the frequency of non-compliance reports – in the implementation of the proposed rule.

The alternative scenario in the turkey-*Salmonella* model suggests a small reduction in the probability that the *Salmonella* illness rate will increase (i.e., from 0.20 to 0.14). The alternative scenario in the turkey-*Campylobacter* model suggests only a minor change relative to the indiscriminate analysis.

For the alternative scenario, the combined illnesses avoided results demonstrate a substantial decrease in the probability that illnesses might increase for young chicken establishments (i.e., from 0.13 to 0.0009). This result for young turkey establishments is less dramatic (i.e., from 0.13 to 0.06). These results suggest that aggregate human illnesses will be unchanged - or decrease - with approximately 100% and 94% confidence among young chicken and young turkey establishments, respectively, if increasing unscheduled procedures is emphasized in the proposed rule.

Table 5. Summary statistics for human illnesses avoided from Monte Carlo simulations of the indiscriminate scenario across the four product-pathogen models.

	Attributable to Young Chicken Establishments		**Attributable to Young Turkey Establishments**		**Combined Illnesses Avoided**	
Statistic	***Salmonella* illnesses avoided**	***Campylobacter* illnesses avoided**	***Salmonella* illnesses avoided**	***Campylobacter* illnesses avoided**	***Salmonella* illnesses avoided**	***Campylobacter* illnesses avoided**

Mean	4,203	-462	311	119	4513	-341
Median	3,806	-3	270	95	4109	51
Mode	3,181	0	161	0	3059	1
Std Deviation	3,018	2,216	423	106	3110	2230
10th percentile	872	-2,668	-146	9	1075	-2590
90th percentile	8,089	1,067	834	252	8534	1222
Probability of increased illnesses	0.0465	0.6268	0.198	0.0086	.0407	.4000

Table 6. Summary statistics for human illnesses avoided from Monte Carlo simulations of an alternative scenario that increases unscheduled procedures across the four product-pathogen models.

	Attributable to Young Chicken Establishments		**Attributable to Young Turkey Establishments**		**Combined Illnesses Avoided**	
Statistic	***Salmonella* illnesses avoided**	***Campylobacter* illnesses avoided**	***Salmonella* illnesses avoided**	***Campylobacter* illnesses avoided**	***Salmonella* illnesses avoided**	***Campylobacter* illnesses avoided**
Mean	4,044	868	242	118	4286	986
Median	3,567	174	187	95	3804	326
Mode	2,483	0	90	0	2995	1
Std Deviation	2,463	1,626	285	104	2548	1620
10th percentile	1,390	0	-30	12	1514	26
90th percentile	7,301	2,728	603	249	7682	2865
Probability of increased illnesses	0.0001	0.1044	0.1368	0.0004	.0058	.0501

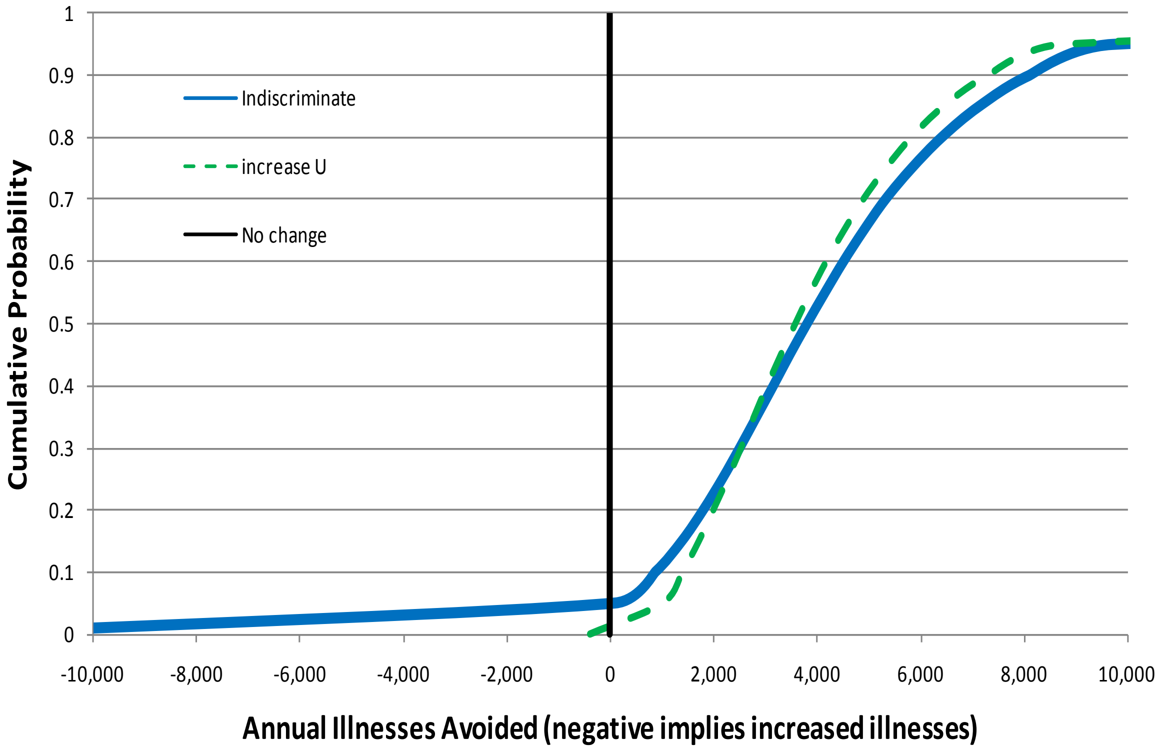

Figure 1. Uncertainty about the change in the annual *Salmonella* human illness rate when off-line inspection procedures are intensified in chicken establishments is depicted for the indiscriminate scenario, the increased unscheduled procedures scenario and the decreased scheduled but not performed procedures scenario.

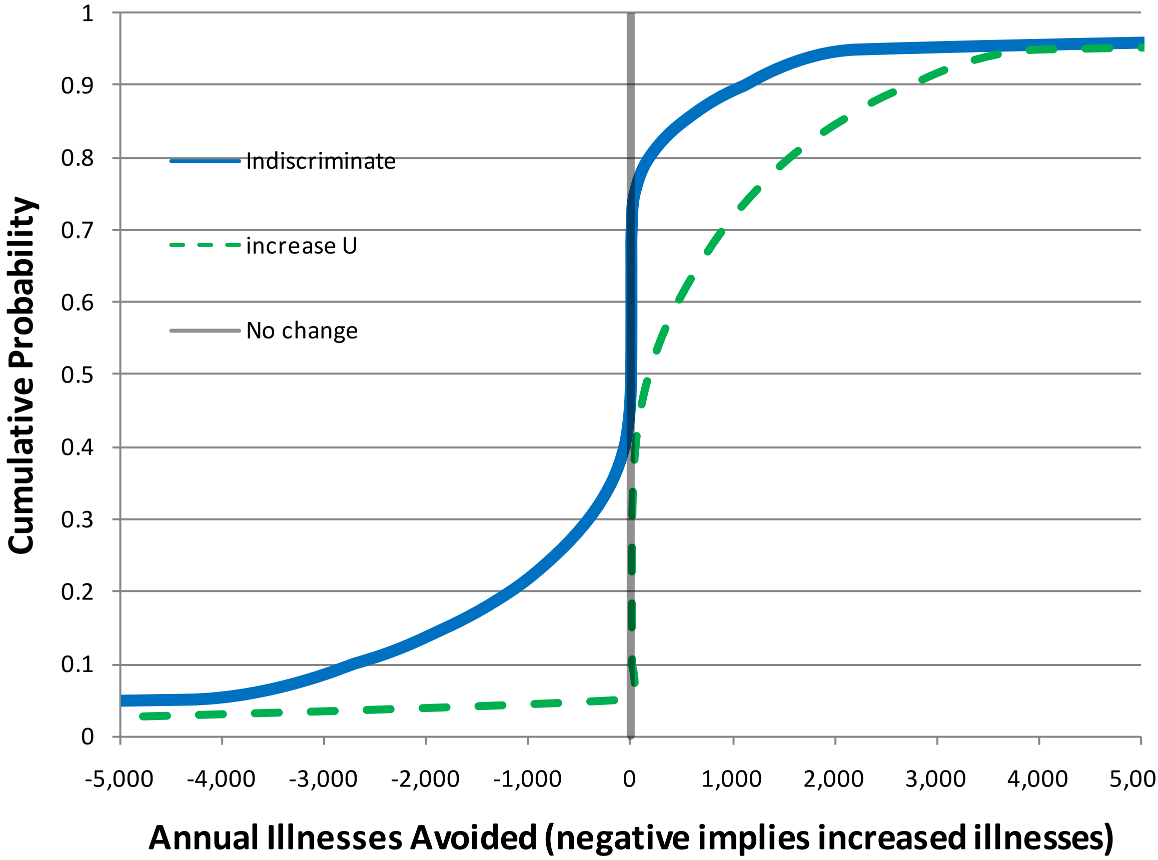

Figure 2. Uncertainty about the change in the annual *Campylobacter* human illness rate when off-line inspection procedures are intensified in chicken establishments is depicted for the indiscriminate scenario, the increased unscheduled procedures scenario and the decreased scheduled but not performed procedures scenario.

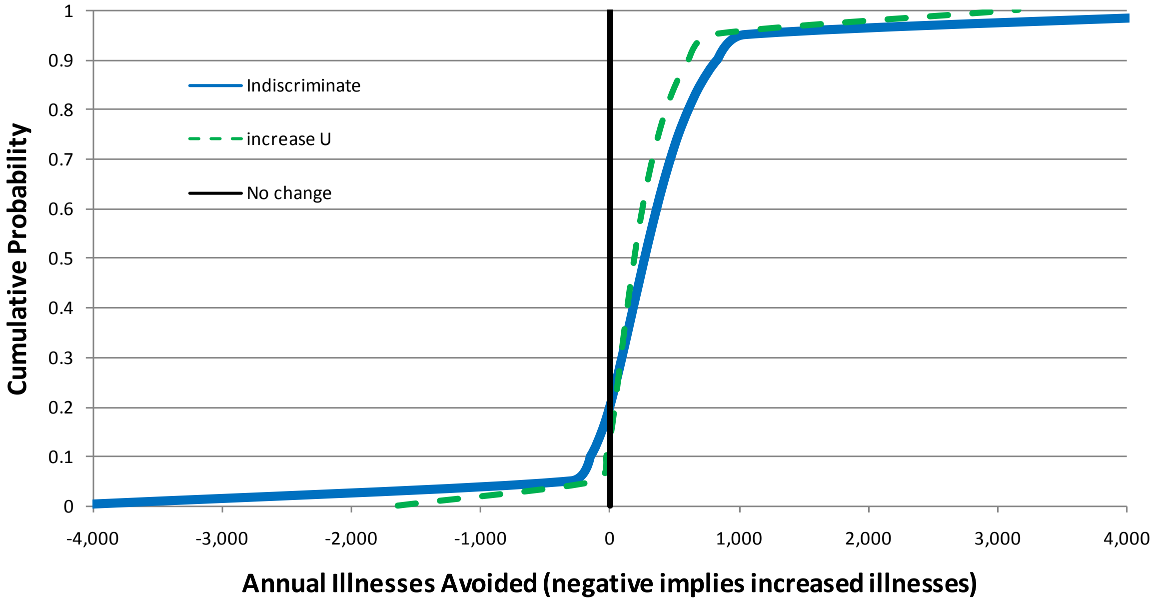

Figure 3. Uncertainty about the change in the annual *Salmonella* human illness rate when off-line inspection procedures are intensified in turkey establishments is depicted for the indiscriminate scenario, the increased unscheduled procedures scenario and the decreased scheduled but not performed procedures scenario.

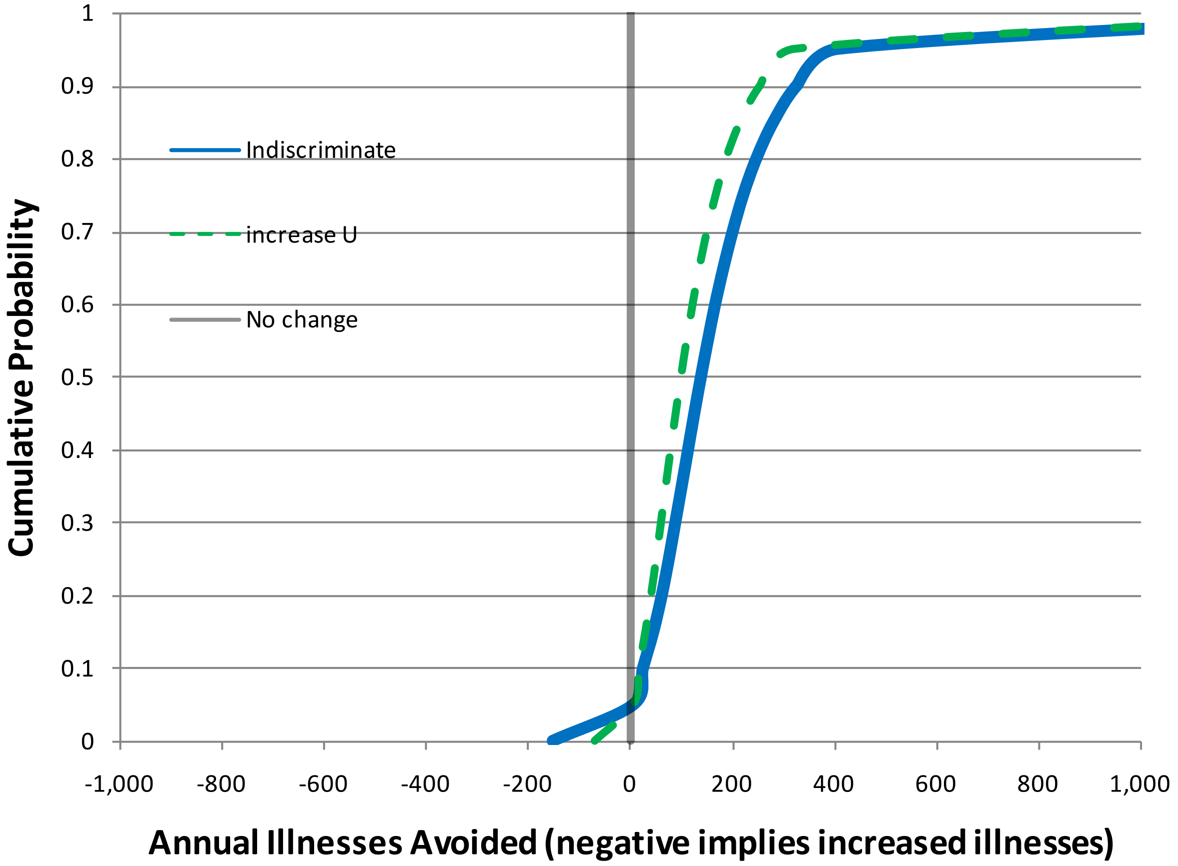

Figure 4. Uncertainty about the change in the annual *Campylobacter* human illness rate when off-line inspection procedures are intensified in turkey establishments is depicted for the indiscriminate scenario, the increased unscheduled procedures scenario and the decreased scheduled but not performed procedures scenario.

DISCUSSION

In the model and analyses presented here we examine available data to establish quantitative relationships between observed *Salmonella* and *Campylobacter* positive samples and Agency inspection activities taking place in young chicken and young turkey slaughter establishments. While this does not establish a cause-and-effect relationship, we can draw inferences from these observed associations. We further assume that there is a relationship between observed *Salmonella* and *Campylobacter* positive samples in young chicken and young turkey slaughter establishments and attributable human illnesses from chicken and turkey consumption (11). A great deal of the quantitative portion of this risk assessment focuses on these two relationships.

The risk assessment provides answers to each of the four risk management questions.

- *Can FSIS reallocate inspection activities in young chicken slaughter establishments without significant negative impact on microbial prevalence in the establishments?*

  In general, this analysis suggests that the proposed change in off-line inspection will decrease the net annual human illness rate with high probability and that the probability of proposed changes in off-line inspection procedures increasing the annual rate of human illnesses is small. and dependent on how the rule is implemented in practice.

  This analysis also suggests ambiguous effects with respect to *Campylobacter* occurrence among chicken establishments. The larger probability of increased *Campylobacter* illnesses from contaminated chicken carcasses is primarily driven, however, by the non-compliances decision variable. This decision variable is poorly understood and the intended effect of changes in this category of procedures is arguable. Removing the effect of this decision variable in alternative scenarios substantially reduces the probability that the human illness rate might increase.

  This latter conclusion is further supported by consideration of the HIMP structural variable in the chicken-*Campylobacter* regression model (see Appendix). That model suggests that participation in HIMP was associated with a reduced prevalence of *Campylobacter*. Although *Campylobacter* occurrence was not considered in an analysis of HIMP establishments (13), these regression findings suggest that the positive *Salmonella* implications of that HIMP analysis also apply to *Campylobacter*.

  The HIMP structural variable in all four regression models implied participation in HIMP was associated with reduced pathogen prevalence. While not a focus of this risk assessment, the regression model’s implication about HIMP establishments should provide some measure of confidence about the effects of the proposed rule – which intends to replicate HIMP across a wider swath of the poultry industry.

- *How will the relocation of on-line inspectors to off-line duties, or other areas within or outside the establishment, affect human illness?*

  Most likely point estimates from a scenario that indiscriminately changes all four decision variables in our analysis suggest a net reduction of 3,342 (3,181+161, from Table 3) in the annual rate of *Salmonella* illnesses. This analysis assumes that the total annual *Salmonella* illnesses rate attributed to poultry is centered about 174,686 (167,831+6,855, from Table 2). Therefore, an increase in off-line inspection activities might be expected to prevent ~1.9% of these illnesses per year.

  Most likely point estimates from the same scenario suggest that there will be no net change in the annual rate of *Campylobacter* illnesses in either chicken or turkey establishments.

- *Where within the establishment can relocated inspection activities have the most impact toward reducing microbial prevalence and corresponding human illness?*

  The most reliable implication from the regression models is that increasing unscheduled procedures seems to reduce pathogen occurrence on carcasses. The other decision variables suggest ambiguous effects from their intended changes when those effects are considered across all four pathogen-product models.

- *What is the uncertainty about these effects?*

  Our modeling approach includes uncertainty about regression coefficients, uncertainty as to the effective change in future inspection activities , and uncertainty in the baseline annual rates of human Salmonella and Campylobacter illness attributable to poultry. These sources of uncertainty translate into substantial uncertainty about forecasted changes in illness rates.

  The focus of this analysis is on the “down-side” potential of the proposed rule (i.e., the probability that illness rates might increase). This focus seems appropriate for a proposed rule that intends to change inspection processes in slaughter establishments. Nevertheless, the uncertainty about changes in illness rates includes “up-side” potential that a public health benefit in the form of illnesses avoided could be substantially larger than the model values cited.

  The uncertainty that surrounds these forecasts suggests further monitoring opportunities for FSIS.. For example, FSIS can periodically assess aggregate inspection procedures and compare these to the baseline predictions from this model. Such comparisons will empirically measure the changes occurring for the decision variables in the model and reduce the current uncertainty about these model inputs. Also, FSIS will continue to monitor the pathogen prevalence on carcasses among participating and non-participating establishments. The pathogen verification testin data can be used to assess correspondence with its expectations..

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APPENDIX

Regression Modeling Methods and Observational Datasets

This appendix explains the results of regression modeling that are the foundation of this risk assessment. It is here that evidence about the occurrence of pathogens on poultry carcasses is statistically linked to evidence about possible explanatory variables. Based on these findings, the body of this report forecasts human illnesses avoided following implementation of the poultry slaughter rule.

The proposed rule intends to shift some on-line inspectors to off-line inspection duties. We assume that the increased off-line inspection work force will – because of apparent correlations between performance of inspection procedures and occurrence of pathogens on carcasses – influence public health exposures to these foodborne pathogens.

We developed regression models to assess the strength of relationships between the performance of off-line inspection procedures and the prevalence of *Salmonella* and *Campylobacter* on young chicken and young turkey carcasses. We estimated a binary logistic regression with coefficients that are weighted by slaughter volume.

Previously, the basic modeling approach was peer reviewed and revised (2). In this version, we increased the number of samples and variables evaluated. We used our prior experience with the logistic regression modeling of FSIS poultry slaughter sampling verification methods – and inspector procedure data – to update the model. Also, this version included modifications in response to comments from the National Advisory Committee on Meat and Poultry Inspection (NACMPI) after release of a 2008 FSIS Risk Assessment.

Regression Model Approach

Four basic regression models are estimated to account for the two target pathogens (*Salmonella sp*. and *Campylobacter sp*.) and two major poultry classes (young chickens and young turkeys). For each product-pathogen pair, a multivariate logistic model is fit. Each model accounts for slaughter volume and the clustered (and correlated) nature of the data available from slaughter establishments. Each model uses pseudo-likelihood estimation and employs a correction for over-dispersion.

Each model evaluates pathogen prevalence in relation to four off-line inspection procedure categories; (i) scheduled and performed, (ii) scheduled but not performed, (iii) unscheduled, and (iv) non-compliances. These four categories of inspection procedures encompass the totality of procedure elements across six classes of standard off-line procedures completed by FSIS personnel: (i) sanitation, (ii) HACCP, (iii) wholesomeness/economic consumer protection, (iv) sampling, (v) sanitation performance standards, and (vi) emergency procedures.

We chose the four defined categories because the expected/intended effect of the proposed policy was consistent for procedures within each category. For example, the proposed increase in off-line inspectors is expected to increase scheduled and performed procedures. Similarly, increased availability of off-line inspectors should increase unscheduled procedures while reducing scheduled but not performed procedures. We also assume that – in the long-run – reported non-compliances will decrease with more off-line inspectors in slaughter establishments because such establishments will attain appropriate process control. Although we explored an alternative approach that collapsed decision variables according to the six classes of off-line procedures, this approach created confusion about the intended effect of the proposed policy within each class. For example, a random variable that summarized HACCP procedures would need to increase scheduled and performed procedures (and unscheduled procedures) but also decrease scheduled but not performed procedures (and non-compliances).

Because of the observational nature of the data, a set of structural variables were used to control confounding. These structural variables pertained to non-inspection activities but included consideration of establishment size, temporal, spatial and other establishment factors.

The regressions are estimated using SAS Proc Logistic version 9.1 software (4). The logit link function is used for the dependent variable and pseudo-maximum likelihood estimates of the structural and decision variable regression coefficients are obtained using the Fisher scoring algorithm. Wald statistics are calculated for assessing the significance of regression coefficients.

The general form of the binary model relating unconditional probabilities (p) to the regression coefficients (b_i) in standardized form with X_i's as the regressors is:

$$p = \exp(b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_n X_n) / (1 + \exp(b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_n X_n))$$

The logit link function relating the log of the odds ratio (p/(1-p)) to the standardized regression coefficients is:

$$\log(p/(1-p)) = b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_n X_n$$

Each binary logistic regression model was evaluated for lack of fit to the data using the standard Hosmer-Lemeshow test (5). All models are required to pass this test for fit to the logistic distribution. Model over-dispersion was evaluated with the Pearson chi-square divided by the degrees of freedom. The dispersion parameter statistic indicating over-dispersion requires multiplication of the covariance matrix to correct for the over-dispersion when greater than 1.05 (6). This adjustment converts the regression coefficient estimates to quasi-likelihoods and appropriately decreases the regression coefficient significance by increasing the standard errors of the estimates effectively converting the model dispersion parameter to unity.

Unconditional maximum likelihood estimates are used because the total sample size in the data structure is sufficiently large (7). A conditional analysis was assessed, but offered no advantage. The conditional analysis shows an advantage when the total sample size is small (in the hundreds or less). The expected requirements for a valid unconditional maximum likelihood analysis are met for both the *Salmonella* and *Campylobacter* datasets.

Data Sets

The core data come from the FSIS "Young Chicken Baseline" (July 2007 through September 2008, 8) and the FSIS "Young Turkey Baseline" (August 2008 through July 2009, 9). Both baselines provide data for *Salmonella* and *Campylobacter* sampling at rehang and post-chill locations. These data are supplemented with young chicken and young turkey data from the FSIS PR/HACCP *Salmonella* verification program (July 2007 through September 2010).
Data from 189 young chicken slaughter establishments provided 6,558 Baseline results for *Salmonella* and *Campylobacter,* with an additional 16,115 PR/HACCP post chill results added to the *Salmonella* dataset. In the Baseline data there were 3,379 samples taken at rehang and 3,278 taken at post chill. There are 2,790 positive *Salmonella* results out of 22,671 total results, and 4,809 positive *Campylobacter* results out of 6,558 total results.

For young turkeys, there were 65 establishments in the *Salmonella* dataset and 58 establishments in the *Campylobacter* dataset. The *Salmonella* dataset had 8,749 samples (2,884 baseline and 5,865 regulatory) of which 638 (7.29%) were positive and the *Campylobacter* dataset had 2,884 samples of which 343 (11.89%) were positive.

Decision variables: Inspection procedures

There are six general inspection system procedure (ISP) code activity categories captured in the FSIS database (Table 1). Sums of daily scheduled and unscheduled procedures performed – as well as unperformed procedures and non-compliance reports – for individual establishments were matched with same-day positive and negative *Salmonella* or *Campylobacter* results.
The ISP codes from the FSIS database were tabulated daily for all scheduled procedures, unscheduled procedures, uncompleted procedures, non-compliances, and total procedures performed for each establishment. Scheduled procedures are assigned to each establishment's shift according to a systematic process by an automated Performance-Based Inspection System. Unscheduled procedures are performed according to in-establishment inspector needs; they typically involve regulatory inspection activities such as fecal checks for zero-tolerance. Unscheduled procedures are also performed in response to unforeseen hazards, unsanitary conditions arising from Sanitation Standard Operating Procedures (SSOP) failures, and PR/HACCP corrective actions.

Among the six general ISP procedure activities, 47 specific ISP procedure codes were used. These included five Sanitation codes, 17 PR/HACCP codes, 11 Wholesomeness/Economic Consumer Protection codes, six Sampling codes, four Other Inspection Requirements codes and four Emergency Activity codes (Table 1). Ultimately, these specific codes were designated in the database as scheduled and performed (SP), scheduled and not performed (SNP), unscheduled (U) and non-compliance (NC).

The total activity for each of these four categories was calculated as the sum across all codes for that category:

SP = scheduled and performed procedures for sanitation(01), HACCP(03), wholesomeness/economic consumer protection(04), sampling(05), other inspection requirements(06), sanitation performance standards (06D01), raw ground (03B), raw not ground (03C), fecals (03J), economic poultry kill (04C04)

SNP = scheduled not performed procedures for sanitation(01), HACCP (03), wholesomeness/economic consumer protection(04), sampling (05), other inspection requirements (06), sanitation performance standards(06D01), raw ground (03B), raw not ground (03C), fecal(03J), economic poultry kill (04C04)

U = unscheduled procedures performed for sanitation(01), HACCP(03), wholesomeness/economic consumer protection(04), sampling(05), other inspection requirements(06), sanitation performance standards(06D01), raw ground(03B), raw not ground(03C), fecals (03J), economic poultry kill (04C04), emergency procedures (08)

NC = non-compliant procedures for sanitation(01), HACCP(03), wholesomeness/economic consumer protection(04), sampling(05), other inspection requirements(06), sanitation performance standards(06D01), raw ground(03B), raw not ground(03C), fecals(03J), economic poultry kill(04C04).

Structural variables: Non-inspection procedures

A minimal set of structural variables were found to contribute most to reducing the model deviance, controlling confounding and providing the best overall model fit to the data as assessed by the Hosmer-Lemeshow test. Structural variables were selected using forward regression in the SAS logistic procedure with the probability to enter the model taken as 0.05. Twelve of nineteen tested structural variables provided the best model[4] (i.e., the inclusion of these structural variables significantly reduces the model deviance). These structural variables are:

1. The **re-hang** variable distinguishes between locations of sample collection (where 1 signifies post-chill samples and 0 signifies re-hang samples).
2. The **categorical month** variable breaks down the time dependency into 39 consecutive months. The last study month in 2010 is used as reference. In the case of *Campylobacter* this variable was shortened to 12 months due to only one year of data being available.
3. The **categorical district** variable differentiates the 15 districts. District 90 is used as the reference.
4. **Line-speed**,
5. **Number of establishment inspectors**,
6. **Line count**
7. The **categorical inspection system** variable identifies 22 inspection type combinations (Table 5) from the eight basic types (MAESTRO, NELS, Nu-Tech, Nuova, SIS, HIMP, Traditional, and Religious Slaughter). Traditional inspection is used as the reference.

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[4] Variables that were considered but are excluded because of less contribution or overlapping contribution to the model fit to the data are HACCP size, production area, inspector positions, time in weeks (52), time in months (12), time in quarters (4 and 12), time in years (4), and time from grant of inspection date.

(Table 8 shows these categories for young chicken while Table 9 shows the shorter list for young turkey)

8. The binary **HACCP Inspection Models Project (HIMP) variable** appears separately in the young chicken models and examines the HIMP establishment model contribution. Non-HIMP establishments are used as the reference.
9. **septicemia-toxemia** condemnations of carcasses,
10. **contamination** (fecal, ingesta, body fluids, etc.) of carcasses, and
11. **air sacculitis** cases among carcasses
12. **synovitis** cases among carcasses (only a relevant disease to the turkey slaughter).

Final Models

Tables 2 and 3 list the estimated regression coefficients, standard errors, the means and the standard deviations for all decision and structural variables in the young chicken models. Tables 4 and 5 show these estimates for young turkey. The same structural variables were used in each of the models to compensate for confounding. Some coefficients have non-significant contributions according to a 0.05 significance assumption but were retained in the model for consistency across all four models.

Among the four decision variables, a common finding across all four models was that the coefficient for unscheduled procedures was consistently negative. This finding suggests that increasing these procedures (while holding other variables constant) will decrease the prevalence of *Salmonella* and *Campylobacter*. Nevertheless, the U procedures variable is only statistically significant in the chicken-*Salmonella* and turkey-*Campylobacter* models.

Among structural variables, a common finding was the (statistically significant) negative coefficient for HIMP participation across all four models. The HIMP participation variable is a separate structural variable in the chicken models, but it is incorporated into an inspection system variable in the turkey models. This finding suggests that when this variable is assigned a value of one (indicating participation in HIMP), the prevalence of *Salmonella* and *Campylobacter* predicted by the model is lower than when the alternative (non-HIMP) participation value is assigned[5].

The baseline post-chill prevalence predictions from each model are derived by setting the rehang structural variable to one. Comparing these predictions to production-volume weighted prevalence values from the data suggests that the model reasonably reflects the empiric evidence. For example, the chicken-*Salmonella* model predicts a post-chill prevalence of 0.058 versus a weighted average of 0.053 from the raw data. The chicken-*Campylobacter* model predicts a post-chill prevalence of 0.63 versus a weighted average of 0.61 from the raw data. The turkey-*Salmonella* model predicts a post-chill prevalence of 0.046 versus a weighted average of 0.069 from the raw data. The turkey-*Campylobacter* model predicts a post-chill prevalence of 0.009 versus a weighted average of 0.008 from the raw data. Differences between predicted and raw values generally reflect the additional weighting for other structural factors (e.g., temporal

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[5] This alternative value is -1 for the chicken-*Salmonella* model and zero for the other models.

factors, spatial factors, line speed, HIMP participation, etc.) included in the predicted values (but not included in the simple weighting of the raw data prevalence levels).

Alternative models were assessed by using 43 and 21 decision variables. These alternatives represented the 43 non-emergency procedures listed in Table 1 and a collapsing of these to 21 variables. Models were compared with respect to three statistics; the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC-Schwartz), and the coefficient of determination (R-squared). For the young chicken-*Salmonella* model, the four decision variable model was best according to all statistics. For the young chicken-*Campylobacter* model, the BIC and R-squared statistics indicated the four decision variable model was best, although the AIC suggested the 21-variable model was preferred. For the young turkey models (*Salmonella* and *Campylobacter*), only the BIC statistic supported the four variable model while the other models were each preferred by different statistics. Nevertheless, to maintain consistency when forecasting effects of the proposed policy, we selected the four decision variable model for each product-pathogen pairing. The R-square values for these chicken-*Salmonella*, chicken-*Campylobacter*, turkey-*Salmonella* and turkey-*Campylobacte*r models are 0.27, 0.09, 0.10 and 0.33, respectively.

For model evaluation and validation, we randomly split the datasets used in model development, re-estimated the regression coefficients for each subset of data and assessed the stability of the prevalence estimates.

Tables 6 and 7 show the results of splitting the young chicken datasets for *Salmonella*. Table 6 shows the parameter estimates for the un-split data model estimates and also for the two split halves of data. Table 7 shows the prevalence estimates from each of the models compared to the unadjusted prevalence estimates from the full dataset. The model appears to be stable when splitting the data since all estimates for the mean, rehang, and post-chill prevalence are in close agreement. Also, the post-chill prevalence is within the sampling error of the post-chill prevalence found in the FSIS HIMP report (13). The only matter of concern is the prediction of the mean prevalence which is lower than the unweighted overall prevalence. This is likely due to the model weighting compensating from the relatively high prevalence at re-hang and the low prevalence at post-chill.

Similarly, the results for splitting the young chicken *Campylobacte*r dataset are shown in Tables 8 and 9. The parameter estimates from Table 8 are used to calculate the prevalence estimates in Table 9. The BX element in Table 9 is the sum of cross products of the B regression parameter and the mean variable components in the model. By back transforming BX through the inverse logit function the estimated prevalence is obtained. The prevalence estimates for the mean, rehang, and post-chill are consistent within the sampling error across the dataset splits. There is no external comparison data for *Campylobacte*r.

Tables 10 and 11 show the dataset splitting results for young turkey *Salmonella*. All the prevalence estimates are consistent with sampling error across the splits of data and agree with the full dataset estimates. The estimates are in agreement with the high unweighted *Salmonella* prevalence.

Tables 12 and 13 show the dataset splitting results for young turkey *Campylobacte*r. This model has the smallest number of observations and the expectation with split datasets is that there will be some variability not seen with the larger datasets. This is in fact the case. For although the rehang and post-chill estimates are in relatively close agreement there is variation with the mean estimates which tend to be lower than the unweighted prevalence estimate. Since this is a concern further model evaluation is warranted.

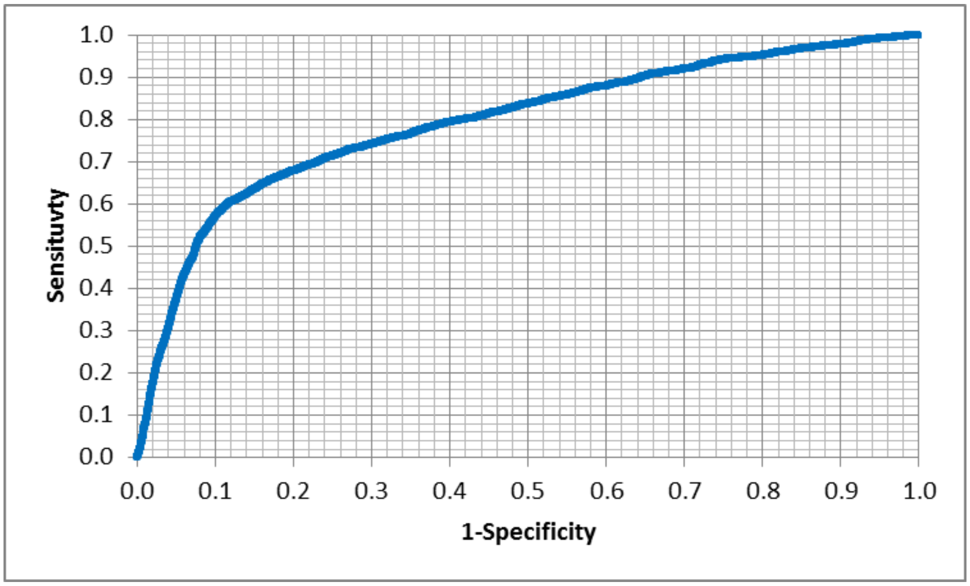
Figures 1-4 show the Receiver Operating Characteristic (ROC) plots for the four models. The interpretation of these plots is that the model is more predictive the farther away the curve is away from the imaginary diagonal dividing the figure in halves. The best predictors are the closest to the 100% sensitivity and 0% 1-Specifity corner point. A standard method for evaluation is to estimate the area under the curve. This can be done using the SAS logistic procedure output for binary response models. The c-statistic is equivalent to the area under the curve (AUC). The predictive order of c coefficients across the four models is 0.702, 0.710, 0.792, and 0.852, making the young chicken *Campylobacter* the least predictive, young turkey *Salmonella* somewhat more predictive, young chicken *Salmonella* still more predictive, and the young turkey *Campylobacter* model the most predictive. However, all models are sufficiently predictive with areas under the curve all greater than 0.7.

Because the analysis so far shows that the unscheduled procedures regression coefficients are consistent in sign and generally significant across all four models, curiosity about what the four model sets expanded for only unscheduled procedures might look like was undertaken. Because the turkey-*Salmonella* model does not have a significant aggregate coefficient only the three remaining models were considered. Therefore, the previously aggregated sets of sanitation, HACCP, wholesomeness/economic consumer protection, sampling, other inspection requirements, and emergency procedures were disaggregated and put into each of the models with their respective structural variables. Table 14 shows the results for the three models. The results are mixed between significant negative coefficient signs for decreased prevalence and significant positive coefficient signs for increased prevalence. Because of the aggregate significant negative sign coefficients for two of the four models, focusing on the same type of significant negative coefficient in the disaggregated models seemed justified. The 03, 04, and 06 procedure elements have this characteristic in the chicken-*Salmonella* model and the 04 and 05 procedures elements behave similarly in the chicken-*Campylobacter* model with the 03 element almost significant. The turkey-*Campylobacter* model has the 03 and 06 elements significant. It is not clear why the 05 and 06 coefficients have significant positive signs in the chicken models. Table 15 shows the results for further disaggregated models. It becomes clear that the 03J procedures are the drivers decreasing prevalence for HACCP in the chicken-*Campylobacter* model and the 06D01 procedures are drivers for other inspection requirements in the chicken-*Salmonella* and turkey-*Campylobacter* models. The prevalence estimates from these models shown in Table16 indicate the same consistent predictability and validity associated with the subset models that was verified with the same collinearity analysis.

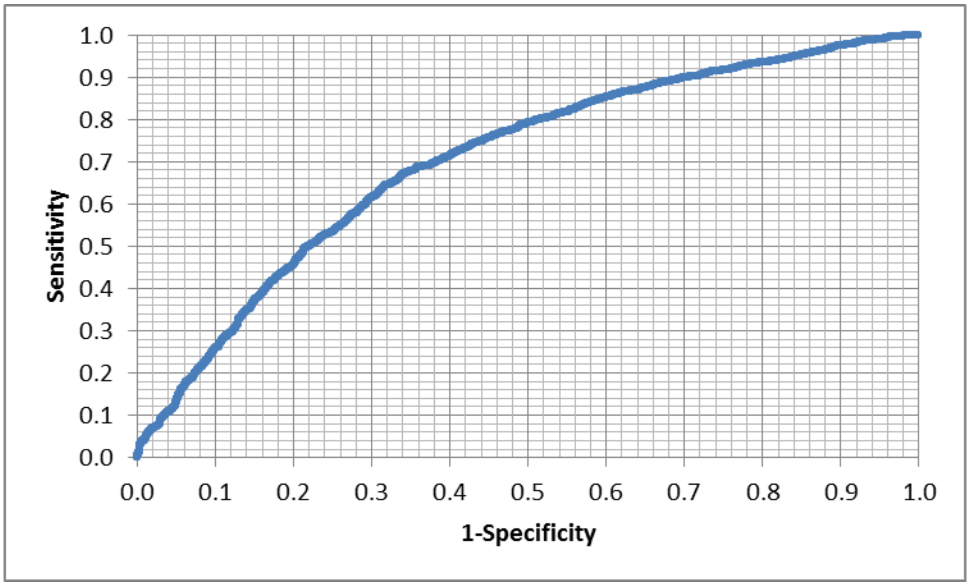
PRIA Dataset Evaluation

Because the original observational dataset used to develop the four models for scenario analysis excluded some of the establishments that are predicted to adopt the new inspection system requiring a shift of the majority of on-line inspectors to off-line inspection duties while leaving one inspector on-line for final carcass inspection according to the Preliminary Regulatory Impact Analysis (PRIA) of the proposed poultry slaughter rule, we decided to create a simulated dataset corresponding to all establishments expected to adopt the new inspection system. Looking at the establishment breakdown by the small business administration (SBA) size classification of large, small, and very small establishments (L, S, V) we noticed that there is an imperfect match and additionally none of the very small establishments in the observational dataset are expected to adopt the new inspection system. Table 17 shows the breakdown for SBA size for the observational study and Table 18 shows the expected size breakdown for establishments that will adopt the new inspection system according to the PRIA. Therefore, four simulated datasets were constructed based on the known characteristics studied in the observational analysis and using substituted known values according to matched establishment characteristics based on the list of establishments expected to adopt the new inspection system. Repeated random selection of establishments with matching characteristics created an averaged dataset corresponding to the characteristics of the establishment distribution of establishments expected to adopt the new inspection system.

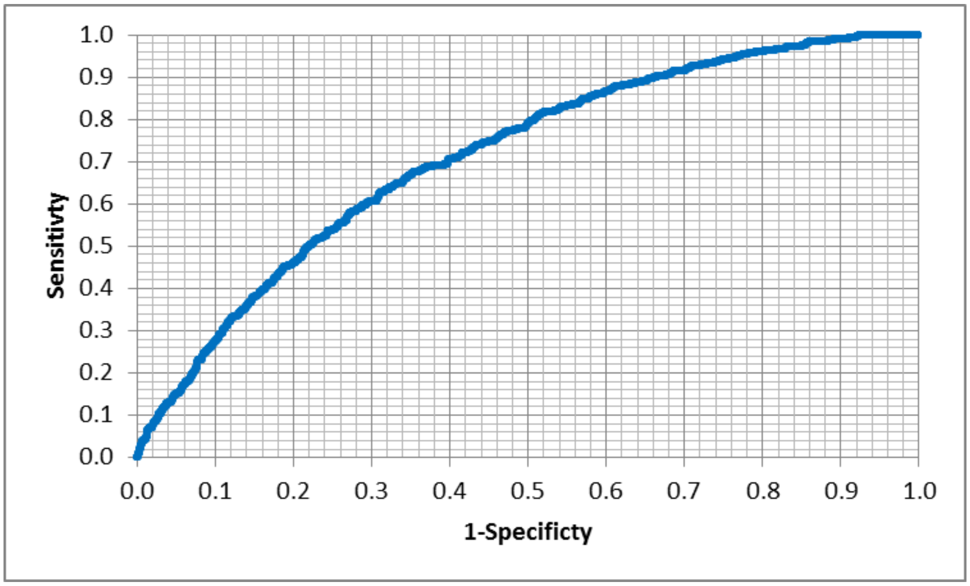
It was found that each of the four observed datasets could be recast to resemble the distribution of establishments expected to adopt the new inspection system as shown in Table 19. The 19 establishments in the "other" category were placed in either the chicken or the turkey datasets according to size and predominant production characteristics. The 19 "other" establishments accounted for all the very small establishments in the expected datasets. However, upon further inspection it became apparent that all but the small establishments in the *Salmonella and Campylobacter* young chicken datasets were subsets of the original four observed datasets. This meant that 4% and 10% of the small plants from these two datasets would have to be reused in recasting the expected distributions for the young chicken *Salmonella and Campylobacter* models. This was not a problem when all four datasets were recast as expected datasets for logistic regression analysis and the four expected dataset prevalence estimates were found to be within the prevalence error of each the observed datasets (Table 20). It is therefore assumed that the results of the four observed dataset models contain the results of the four expected dataset models and that no further analysis is required because the conclusions of the risk assessment contain the same conclusions that can be drawn from the expected datasets.



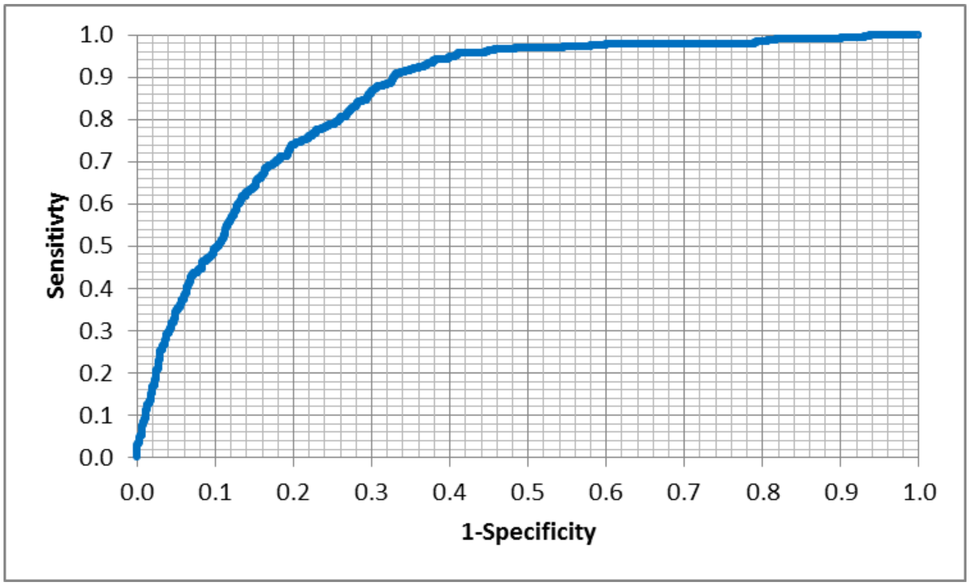
Appendix Figure 1. ROC Plot of Sensitivity against 1-Specificity with an AUC of 0.792 for the Young Chicken *Salmonella* Predictive Model



Appendix Figure 2. ROC Plot of Sensitivity against 1-Specificity with an AUC of 0.702 for the Young Chicken *Campylobacter* Predictive Model



Appendix Figure 3. ROC Plot of Sensitivity against 1-Specificity with an AUC of 0.710 for the Young Turkey *Salmonella* Predictive Model



Appendix Figure 4. ROC Plot of Sensitivity against 1-Specificity with an AUC of 0.852 for the Young Turkey *Campylobacter* Predictive Model

TABLES

Appendix Table 1. Inspection System Procedure (ISP) Code Listing of Individual and Summed Codes, used as Independent Variable Identifiers for Daily Sums of Procedures Scheduled, Performed, Unscheduled, and Non-Compliant in the Binary Logistic Regression Model

	Code Sum	**Activity**	**Other Sum**	**Elements**		**ISP Code**	**Procedures**
1	sum01	sanitation	sum01A	verification	24	01A01	sanitation SOP
2	sum01	sanitation	sum01B	preoperational	25	01B01	m/v/r/ca/fu[4]
3	sum01	sanitation	sum01B	preoperational	26	01B02	01B01 verification
4	sum01	sanitation	sum01C	operational	27	01C01	m/v/r/ca/fu[4]
5	sum01	sanitation	sum01C	operational	28	01C02	01C01 verification
6	sum03	HACCP	sum03A	verification	29	03A01	HACCP plan
7	sum03	HACCP	sum03B	raw ground	30	03B01	m/v/r/ca/fu[4]
8	sum03	HACCP	sum03B	raw ground	31	03B02	03B01 verification
9	sum03	HACCP	sum03C	raw not ground	32	03C01	m/v/r/ca/fu[4]
10	sum03	HACCP	sum03C	raw not ground	33	03C02	03C01 verification
11	sum03	HACCP	sum03E	not heat treated-shelf stable	34	3.00E+01	m/v/r/ca/fu[4]
12	sum03	HACCP	sum03F	not heat treated-shelf stable	35	3.00E+02	03E01 verification
13	sum03	HACCP	sum03F	heat treated-shelf stable	36	03F01	m/v/r/ca/fu[4]
14	sum03	HACCP	sum03F	heat treated-shelf stable	37	03F02	03F01 verification
15	sum03	HACCP	sum03G	fully cooked-not shelf stable	38	03G01	m/v/r/ca/fu[4]
16	sum03	HACCP	sum03G	fully cooked-not shelf stable	39	03G02	03G01 verification

17	sum03	HACCP	sum03H	heat treated-not fully cooked	40	03H01	m/v/r/ca/fu[4]
18	sum03	HACCP	sum03H	heat treated-not fully cooked	41	03H02	03H01 verification
19	sum03	HACCP	sum03I	secondary inhibitors-not shelf stable	42	03I01	m/v/r/ca/fu[4]
20	sum03	HACCP	sum03I	secondary inhibitors-not shelf stable	43	03I02	03I01 verification
21	sum03	HACCP	sum03J	slaughter/fecal	44	03J01	m/v/r/ca/fu[4]
22	sum03	HACCP	sum03J	slaughter/fecal	45	03J02	03J01 verification
23	sum04	W/ECP[1]	sum04A01	yield/shrink	46	04A01	m/v/r/ca/fu[4]
47	sum04	W/ECP[1]	sum04A02	product solution formulation	71	04A02	m/v/r/ca/fu[4]
48	sum04	W/ECP[1]	sum04A03	comminuted/mechanically separated	72	04A03	m/v/r/ca/fu[4]
49	sum04	W/ECP[1]	sum04A04	battered products	73	04A04	m/v/r/ca/fu[4]
50	sum04	W/ECP[1]	sum04B01	product meets standard	74	04B01	m/v/r/ca/fu[4]
51	sum04	W/ECP[1]	sum04B02	packaging/labeling standards	75	04B02	m/v/r/ca/fu[4]
52	sum04	W/ECP[1]	sum04B03	stated label net weight	76	04B03	m/v/r/ca/fu[4]
53	sum04	W/ECP[1]	sum04B04	product identification	77	04B04	m/v/r/ca/fu[4]
54	sum04	W/ECP[1]	sum04C02	humane slaughter requirements	78	04C02	m/v/r/ca/fu[4]
55	sum04	W/ECP[1]	sum04C03	non-food safety product req.	79	04C03	m/v/r/ca/fu[4]
56	sum04	W/ECP[1]	sum04C04	poultry humane slaughter (economic)	80	04C04	m/v/r/ca/fu[4]
57	sum05	sampling	sum05A01	generic *E. coli* record plan	81	05A01	verification
58	sum05	sampling	sum05A02	generic *E. coli* record review	82	05A02	m/v/r/ca/fu[4]
59	sum05	sampling	sum05A03	*Salmonella* in raw products	83	05A03	sample collection
60	sum05	sampling	sum05B01	random product sample	84	05B01	sample collection
61	sum05	sampling	sum05B02	CS/DO/headquarters request	85	05B02	sample collection
62	sum05	sampling	sum05C01	random residue sample	86	05C01	sample collection
63	sum06	OIR/SPS[2]	sum06A01	export regulation compliance	87	06A01	m/v/r/ca/fu[4]
64	sum06	OIR/SPS[2]	sum06B01	custom exempt retail compliance	88	06B01	m/v/r/ca/fu[4]
65	sum06	OIR/SPS[2]	sum06D01	sanit. performance standards	89	06D01	m/v/r/ca/fu[4]
66	sum06	OIR/SPS[2]	sum06D02	facility sanitation compliance	90	06D02	m/v/r/ca/fu[4]
67	sum08	emergency[3]	sum08S14	water systems	91	08S14	unscheduled check
68	sum08	emergency[3]	sum08S15	processing/manufacture	92	08S15	unscheduled check
69	sum08	emergency[3]	sum08S16	storage areas	93	08S16	unscheduled check
70	sum08	emergency[3]	sum08S17	shipping/receiving	94	08S17	unscheduled check

1W/ECP = wholesomeness/economic consumer protection
2 OIR/SPS = other inspection requirements/sanitation performance standards
3 emergency procedures performed under homeland security requirements
4 m/v/r/ca/fu = monitoring/verification/records checks/corrective action to non-compliance/follow up reassessment to corrective action

Appendix Table 2. Parameter Estimates for Young Chicken *Salmonella* Model Used in Scenario Analysis

Parameter	Estimate	Std Error	p-value	Mean	Std Dev
Intercept	-1.8967	0.3123	<0.0001*	1.0000	0.0000
rehang	-1.1699	0.0162	<0.0001*	0.7107	0.7035
loglinespeed	0.4675	0.1553	0.0013*	2.0266	0.1786
logInspectors	-0.2878	0.0823	0.0002*	1.2820	0.2675
lines	-0.0866	0.0184	<0.0001*	2.1464	1.0877
Himp	-0.068	0.0267	0.0054*	0.7518	0.6594
month1	0.3558	0.0846	<0.0001*	-0.0110	0.1598
month2	0.0076	0.0537	0.4437	0.0047	0.2035
month3	0.4576	0.0473	<0.0001*	0.0090	0.2137
month4	0.2492	0.0493	<0.0001*	0.0076	0.2103
month5	0.302	0.0479	<0.0001*	0.0094	0.2145
month6	0.2414	0.0502	<0.0001*	0.0067	0.2082
month7	0.6349	0.0485	<0.0001*	0.0063	0.2073
month8	0.0956	0.0522	0.0335*	0.0056	0.2057
month9	0.1752	0.0499	0.0002*	0.0078	0.2107
month10	0.2302	0.0494	<0.0001*	0.0080	0.2112
month11	-0.1409	0.0525	0.0036*	0.0075	0.2102
month12	0.1534	0.0504	0.0012*	0.0073	0.2097
month13	0.0988	0.0704	0.0803	0.0100	0.2159
month14	0.0228	0.0669	0.3666	0.0152	0.2273
month15	0.0969	0.0753	0.0991	0.0049	0.2040
month16	-0.2017	0.1055	0.0280*	-0.0043	0.1799
month17	-0.7525	0.1801	<0.0001*	-0.0108	0.1606
month18	0.0571	0.0707	0.2097	0.0082	0.2116
month19	0.3435	0.059	<0.0001*	0.0133	0.2232
month20	0.2108	0.0685	0.0010*	0.0075	0.2100
month21	-0.5773	0.1134	<0.0001*	0.0000	0.1916
month22	-0.4173	0.0776	<0.0001*	0.0157	0.2285
month23	-0.4668	0.077	<0.0001*	0.0184	0.2341
month24	-0.3467	0.0821	<0.0001*	0.0099	0.2156
month25	0.0985	0.0731	0.0889	0.0065	0.2077
month26	-0.1432	0.0748	0.0278*	0.0105	0.2169
month27	-0.2187	0.0751	0.0018*	0.0113	0.2189
month28	-0.0124	0.0846	0.4417	0.0014	0.1952
month29	0.2626	0.0865	0.0012*	-0.0026	0.1845

month30	0.075	0.1045	0.2365	-0.0056	0.1763
month31	0.6006	0.1286	<0.0001*	-0.0130	0.1535
month32	-0.2403	0.1991	0.1137	-0.0142	0.1492
month33	-0.2092	0.0766	0.0032*	0.0095	0.2147
month34	-0.1156	0.0544	0.0168*	0.0363	0.2678
month35	-0.5026	0.0634	<0.0001*	0.0380	0.2706
month36	-0.3344	0.064	<0.0001*	0.0298	0.2562
month37	-0.0387	0.0698	0.2896	0.0134	0.2235
month38	0.0351	0.0775	0.3253	0.0061	0.2069
District1	-0.3544	0.1256	0.0024*	-0.2177	0.4311
District2	-0.5096	0.0977	<0.0001*	-0.2097	0.4440
District3	0.3047	0.0815	<0.0001*	-0.2113	0.4416
District4	0.3918	0.1251	0.0009*	-0.2174	0.4315
District5	-0.1139	0.0561	0.0212*	-0.1793	0.4894
District6	-0.0603	0.0388	0.0601	-0.0857	0.5982
District7	-0.0185	0.0491	0.3532	-0.1513	0.5260
District8	-1.2824	0.2123	<0.0001*	-0.2219	0.4240
District9	0.5377	0.0469	<0.0001*	-0.1615	0.5131
District10	0.2689	0.056	<0.0001*	-0.1828	0.4845
District11	0.5986	0.1054	<0.0001*	-0.2130	0.4388
District12	0.3913	0.0449	<0.0001*	-0.1440	0.5350
District13	-0.051	0.0381	0.0904	-0.0781	0.6056
District14	0.0505	0.0392	0.0988	-0.1080	0.5756
InspSysMAESTRO	-0.1228	0.0392	0.0008*	0.3088	0.5336
InspSysMAESTRO,Nu-Tech	-0.1219	0.0777	0.0583	-0.0144	0.2381
InspSysMAESTRO,Religio	0.0269	0.0716	0.3536	-0.0106	0.2461
InspSysMAESTRO-SIS	-0.5622	0.1875	0.0014*	-0.0315	0.1968
InspSysNELS	0.0633	0.0414	0.0631	0.0670	0.3658
InspSysNELS,MAESTRO	0.5052	0.0851	<0.0001*	-0.0236	0.2171
InspSysNELS,NTIS,MAEST	0.7756	0.1451	<0.0001*	-0.0325	0.1942
InspSysNELS,Nu-Tech	-0.3414	0.1383	0.0068	-0.0267	0.2095
InspSysNELS,Nu-Tech,Re	0.6381	0.1179	<0.0001*	-0.0304	0.1998
InspSysNELS,Religious	0.3605	0.0696	<0.0001*	-0.0080	0.2515
InspSysNELS,SIS	0.2929	0.0967	0.0013*	-0.0220	0.2209
InspSysNELS,SIS,Religi	-0.2293	0.1551	0.0697	-0.0296	0.2020
InspSysNu-Ova	-0.8808	0.3005	0.0017*	-0.0333	0.1919
InspSysNu-Tech	-0.1878	0.0477	<0.0001*	0.0886	0.3899
InspSysNu-Tech,Religio	-0.4308	0.1088	<0.0001*	-0.0286	0.2047

InspSysSIS	-0.0361	0.0401	0.1840	0.1452	0.4420
InspSysSIS,MAESTRO	0.3542	0.0586	<0.0001*	0.0011	0.2690
InspSysSIS,MAESTRO,Rel	0.2889	0.1318	0.0142*	-0.0292	0.2031
InspSysSIS,Religious S	-0.3865	0.1259	0.0011*	-0.0255	0.2123
InspSysSIS-Nu-Tech	0.066	0.0898	0.2312	-0.0198	0.2260
InspSysSIS-NuOva	-0.8173	0.1442	<0.0001*	-0.0289	0.2037
Sep_Tox	0.0001	0.000001	<0.0001*	258.0830	282.0689
Contam	0.0005	0.0001	<0.0001*	34.1020	84.5970
AirSac	0.0000	0.0001	0.4960	134.3891	1101.8907
sum_SP	0.0021	0.0021	0.1587	12.9624	6.0291
sum_SNP	0.0461	0.0093	<0.0001*	0.5536	1.0524
sum_U	-0.0032	0.0009	0.0002*	29.1353	20.5648
sum_NC	0.0091	0.0096	0.1716	0.7834	1.1422

**Significant difference for two-sided t-test on the regression coefficient*

Appendix Table 3. Parameter Estimates for Young Chicken *Campylobacter* Model Used in Scenario Analysis

Parameter	Estimate	Std Error	p-value	Mean	Std Dev
Intercept	0.3286	5.8184	0.4775	1.0000	0.0000
Rehang	-0.6359	0.0134	<0.0001*	-0.0003	1.0001
loglinespeed	1.2788	0.2047	<0.0001*	2.0428	0.1626
logInspectors	-0.9754	0.1212	<0.0001*	1.3214	0.2366
lines	0.0497	0.0237	0.0180*	2.1751	1.042
Himp	-0.4332	0.0689	<0.0001*	0.1327	0.3392
month1	-0.1895	0.0713	0.0039*	-0.063	0.3316
month2	-0.0734	0.0429	0.0436*	-0.0085	0.4102
month3	0.5022	0.0444	<0.0001*	0.0063	0.4279
month4	0.2178	0.0427	<0.0001*	0.0012	0.4221
month5	0.2193	0.0418	<0.0001*	0.0075	0.4293
month6	0.116	0.043	0.0035*	-0.0018	0.4184
month7	-0.1053	0.0416	0.0057*	-0.0032	0.4168
month8	-0.0817	0.0424	0.0270*	-0.0055	0.414
month9	0.1315	0.0423	0.0009*	0.0018	0.4228
month10	-0.3165	0.0392	<0.0001*	0.0026	0.4237
month11	-0.2484	0.04	<0.0001*	0.0014	0.4222
District1	-0.3553	0.1548	0.0109*	-0.2318	0.4404
District2	-0.3201	0.1995	0.0543	-0.2353	0.4345
District3	-0.5514	0.1431	<0.0001*	-0.2315	0.4409
District4	-0.3275	0.2135	0.0625	-0.2351	0.4348
District5	0.1098	0.0755	0.0730	-0.1991	0.4906

District6	-0.0589	0.0505	0.1218	-0.082	0.6251
District7	0.2839	0.0656	<0.0001*	-0.17	0.5296
District8	-0.6106	0.152	<0.0001*	-0.2336	0.4373
District9	0.4256	0.092	<0.0001*	-0.2052	0.4817
District10	0.1869	0.0889	0.0178*	-0.2072	0.4788
District11	1.5979	0.2689	<0.0001*	-0.2321	0.4399
District12	-0.2427	0.0589	<0.0001*	-0.1475	0.557
District13	-0.3898	0.051	<0.0001*	-0.0907	0.6169
District14	0.3007	0.052	<0.0001*	-0.0944	0.6133
InspSysMAESTRO	-0.8593	5.8054	0.4412	0.3385	0.5116
InspSysMAESTRO,Nu-Tech	-0.4422	5.8058	0.4696	0.0127	0.2243
InspSysMAESTRO,Religio	-0.0386	5.8061	0.4973	0.0041	0.2048
InspSysMAESTRO-SIS	-0.5936	5.808	0.4593	-0.0131	0.1566
InspSysNELS	-0.77	5.8054	0.4472	0.0718	0.3233
InspSysNELS,MAESTRO	-0.4104	5.806	0.4718	0.0008	0.1964
InspSysNELS,NTIS,MAEST	-1.8641	5.8112	0.3742	-0.0168	0.1441
InspSysNELS,Nu-Tech	10.621	116.1	0.4636	-0.0177	0.1408
InspSysNELS,Nu-Tech,Re	-0.7159	5.8065	0.4509	-0.0087	0.1705
InspSysNELS,Religious	-0.9813	5.8061	0.4329	0.0035	0.2033
InspSysNELS,SIS	-0.4999	5.8065	0.4657	-0.0055	0.1797
InspSysNELS,SIS,Religi	-0.1027	5.8079	0.4929	-0.0128	0.1576
InspSysNu-Tech	-0.8998	5.8055	0.4384	0.1136	0.3722
InspSysNu-Tech,Religio	-0.2656	5.8062	0.4818	-0.0029	0.1869
InspSysSIS	-0.5426	5.8054	0.4628	0.1629	0.4173
InspSysSIS,MAESTRO	-0.8898	5.8056	0.4391	0.0178	0.2353
InspSysSIS,MAESTRO,Rel	0.4083	5.8089	0.4720	-0.0134	0.1556
InspSysSIS,Religious S	-1.1934	5.81	0.4186	-0.0131	0.1566
InspSysSIS-Nu-Tech	-0.0369	5.8069	0.4975	-0.0069	0.1758
InspSysSIS-NuOva	-0.1944	5.8075	0.4866	-0.0119	0.1606
Sep_Tox	0.0005	0.0001	<0.0001*	295.9538	265.3369
Contam	-0.0003	0.0001	0.0014*	49.3667	98.622
AirSac	0.0000	0.0000	0.1587	237.9061	2006.175
sum_SP	0.0076	0.0065	0.1212	6.5629	0.8762
sum_SNP	0.0198	0.0107	0.0321*	0.6929	0.26
sum_U	-0.0014	0.0011	0.1016	31.0927	7.3283
sum_NC	-0.0157	0.0074	0.0170*	1.3634	0.3212

**Significant difference for two-sided t-test on the regression coefficient*

Appendix Table 4. Parameter Estimates for Young Turkey *Salmonella* Model Used in Scenario Analysis

Parameter	Estimate	Std Error	p-value	Mean	Std Dev
Intercept	-3.5814	1.0534	0.0003*	1.0000	0.0000
rehang	-0.4599	0.0622	<0.0001*	0.6704	0.7421
loglinespeed	-0.2945	0.8881	0.3701	1.4698	0.1246
logInspectors	1.5612	0.5439	0.0020*	0.9141	0.198
lines	-0.1717	0.2275	0.2252	1.2725	0.4453
month1	0.7670	0.2418	0.0008*	0.0025	0.2149
month2	0.8158	0.2844	0.0021*	-0.0057	0.1947
month3	0.9719	0.3408	0.0022*	-0.0129	0.1749
month4	0.4361	0.3146	0.0829	-0.0064	0.1929
month5	0.6889	0.3059	0.0121*	-0.0081	0.1884
month6	1.1158	0.2472	<0.0001*	-0.0048	0.1971
month7	0.0318	0.3150	0.4598	-0.0053	0.1959
month8	-0.2106	0.3494	0.2733	-0.0077	0.1896
month9	0.0922	0.3317	0.3905	-0.0071	0.1911
month10	0.4242	0.3176	0.0909	-0.0082	0.1881
month11	0.3148	0.3469	0.1821	-0.0119	0.1779
month12	0.5751	0.4077	0.0792	-0.0154	0.1673
month13	-0.0699	0.5346	0.4480	-0.017	0.1623
month14	0.1461	0.2439	0.2746	0.0066	0.2242
month15	0.1761	0.2183	0.2099	0.0186	0.2489
month16	-0.0216	0.2318	0.4629	0.02	0.2515
month17	-0.5254	0.2975	0.0387*	0.0134	0.2385
month18	-0.4990	0.2798	0.0373*	0.0158	0.2433
month19	-0.1435	0.2746	0.3006	0.0117	0.2349
month20	0.0301	0.2551	0.4530	0.0114	0.2345
month21	-0.2562	0.2700	0.1714	0.0121	0.2359
month22	-0.1792	0.2304	0.2184	0.0369	0.2815
month23	-0.3559	0.2287	0.0599	0.0554	0.3099
month24	0.3405	0.1880	0.0351*	0.061	0.3178
month25	0.2955	0.2031	0.0729	0.0395	0.2858
month26	0.5999	0.3965	0.0652	-0.0122	0.1769
month27	-3.2689	2.8210	0.1233	-0.0138	0.1722
month28	-0.6259	0.6202	0.1565	-0.009	0.1859
month29	-3.4238	2.8103	0.1116	-0.0117	0.1785
month30	-0.0102	0.5741	0.4929	-0.0128	0.1752
month31	0.0199	0.4202	0.4811	-0.0086	0.1871

month32	0.5131	0.3604	0.0773	-0.0099	0.1834
month33	-1.4332	0.6777	0.0172*	-0.0046	0.1977
month34	0.1280	0.3056	0.3377	0.0053	0.2211
month35	-0.4092	0.3445	0.1175	0.0142	0.2401
month36	0.0642	0.2774	0.4085	0.0184	0.2485
month37	0.5597	0.2781	0.0221*	0.0033	0.2167
month38	0.9966	0.2835	0.0002	-0.0045	0.198
district1	-0.0841	0.1910	0.3299	0.1021	0.3295
district2	0.1486	0.2300	0.2591	0.0354	0.2261
district3	0.5899	0.1464	<0.0001*	0.1605	0.3894
district4	0.3528	0.1979	0.0373*	0.0794	0.3001
district5	-1.3221	0.4326	0.0011*	0.035	0.2251
district6	0.0284	0.1970	0.4427	0.0769	0.2965
district7	-1.3599	0.6720	0.0215*	0.0158	0.1801
district8	0.3582	0.2027	0.0386*	0.0552	0.2628
district9	0.5694	0.1552	0.0001*	0.1005	0.3276
district10	-0.1438	0.2189	0.2556	0.0655	0.2795
district11	0.4412	0.8227	0.2959	-0.0046	0.111
district12	-0.0660	0.2531	0.3971	0.0501	0.2539
district13	0.5190	0.1709	0.0012*	0.1098	0.3387
InspSysHIMP	-0.4680	0.2356	0.0235*	0.0507	0.345
InspSysNTIS	-0.1056	0.1150	0.1793	0.7058	0.5278
InspSysOtherNTIS	0.7860	0.2182	0.0002*	0.1017	0.4028
sep_tox	0.0011	0.0005	0.0139*	60.1749	75.9333
contam	0.0053	0.0034	0.0595	3.7394	9.3027
airsac	0.0016	0.0009	0.0377*	8.5823	30.7198
synovitis	0.0012	0.0019	0.2638	5.5832	21.0532
sum_SP	0.0054	0.0121	0.3277	10.7622	6.3381
sum_SNP	-0.0805	0.0408	0.0243*	0.4945	1.0889
sum_U	-0.0208	0.0190	0.1368	6.9431	3.1892
sum_NC	0.0581	0.0223	0.0046*	1.8542	3.6883

**Significant difference for two-sided t-test on the regression coefficient*

Appendix Table 5. Parameter Estimates for Young Turkey *Campylobacter* Model Used in Scenario Analysis

Parameter	Estimate	Std Error	p-value	Mean	Std Dev
Intercept	-13.1301	3.2288	<0.0001*	1.0000	0.0000
rehang	-1.7619	0.1523	<0.0001*	-0.677	1.0002
loglinespeed	7.4946	2.6152	0.0021*	1.4706	0.1266

logemployees	3.6115	1.0235	0.0002*	0.9212	0.1865
lines	-2.7200	0.6853	<0.0001*	1.242	0.4284
month14	-0.3209	0.4314	0.2285	0.0583	0.2372
month15	0.7339	0.3665	0.0227*	0.0943	0.2947
month16	0.6898	0.3639	0.0291*	0.104	0.3076
month17	0.3507	0.3764	0.1758	0.0929	0.2928
month18	0.2939	0.3756	0.2170	0.0874	0.2849
month19	0.5901	0.3813	0.0609	0.0693	0.2568
month20	0.5215	0.3819	0.0861	0.0721	0.2614
month21	0.1840	0.3819	0.3150	0.0818	0.2767
month22	-1.5164	0.4950	0.0011*	0.0867	0.2839
month23	-0.8771	0.4473	0.0250*	0.0777	0.2703
month24	-0.5709	0.4238	0.0890	0.0798	0.2735
month25	-0.2184	0.3940	0.2897	0.0867	0.2839
district1	0.4785	0.3196	0.0672	-0.0576	0.4639
district2	-0.6647	1.0543	0.2642	-0.129	0.3611
district3	0.3415	0.2636	0.0976	0.0069	0.532
district4	0.9143	0.3496	0.0045*	-0.0596	0.4614
district5	0.0481	0.3594	0.4468	-0.0673	0.452
district6	0.3492	0.2922	0.1161	-0.0368	0.4878
district7	-1.5516	0.6421	0.0079*	-0.1047	0.4005
district8	-0.6302	0.3867	0.0516	-0.077	0.4395
district9	-0.2110	0.2587	0.2074	-0.0132	0.5126
district10	0.8127	0.2975	0.0032*	-0.0617	0.4589
district11	-0.9561	1.2489	0.2220	-0.1269	0.3647
district12	1.0358	0.4560	0.0116*	-0.0673	0.452
InspSysHIMP	-1.6265	0.5348	0.0012*	0.1179	0.4359
InspSysNTIS	0.1801	0.1804	0.1591	0.6845	0.5496
InspSysOtherNTIS	0.7410	0.3786	0.0252*	0.0257	0.3332
sep_tox	0.0015	0.0011	0.0864	63.1945	81.9786
contam	0.0023	0.0046	0.3086	3.3797	10.4619
airsac	0.0011	0.0015	0.2317	9.9397	47.0573
synovitis	-0.0067	0.0065	0.1514	4.8176	23.6373
sum_SP	-0.0344	0.0203	0.0451*	10.8187	4.2699
sum_SNP	0.0444	0.0573	0.2192	0.9022	1.3254
sum_U	-0.1027	0.0303	0.0004*	8.8464	3.1642
sum_NC	-0.0548	0.0801	0.2470	0.5374	1.0612

**Significant difference for two-sided t-test on the regression coefficient*

Appendix Table 6. Parameter Estimates from the Young Chicken *Salmonella* Split Datasets

Parameter	B	mean	B split1	mean	B split2	mean
Intercept	-1.8967	1.0000	-3.0788	1.0000	-0.8715	1.0000
rehang	-1.1699	0.7107	-1.2067	0.7105	-1.1434	0.7110
loglinespeed	0.4675	2.0266	1.1160	2.0265	-0.1595	2.0266
logemployees	-0.2878	1.2820	-0.3838	1.2809	-0.1754	1.2830
lines	-0.0866	2.1464	-0.1059	2.1380	-0.0753	2.1549
Himp	-0.0680	0.7518	-0.0001	0.7532	-0.1444	0.7505
month1	0.3558	-0.0110	0.4367	-0.0129	0.2887	-0.0092
month2	0.0076	0.0047	-0.0618	0.0034	0.0957	0.0060
month3	0.4576	0.0090	0.5183	0.0081	0.4234	0.0100
month4	0.2492	0.0076	0.0373	0.0055	0.4472	0.0097
month5	0.3020	0.0094	0.2938	0.0067	0.3088	0.0121
month6	0.2414	0.0067	0.0869	0.0049	0.4057	0.0085
month7	0.6349	0.0063	0.6008	0.0044	0.6795	0.0082
month8	0.0956	0.0056	-0.0525	0.0043	0.2246	0.0070
month9	0.1752	0.0078	0.0918	0.0083	0.2367	0.0072
month10	0.2302	0.0080	0.1706	0.0086	0.3204	0.0073
month11	-0.1409	0.0075	-0.1608	0.0064	-0.0815	0.0086
month12	0.1534	0.0073	0.1047	0.0068	0.2069	0.0079
month13	0.0988	0.0100	0.2928	0.0075	-0.0415	0.0125
month14	0.0228	0.0152	-0.1733	0.0143	0.2070	0.0161
month15	0.0969	0.0049	0.0846	0.0023	0.1151	0.0076
month16	-0.2017	-0.0043	-0.4168	-0.0056	-0.0051	-0.0030
month17	-0.7525	-0.0108	-0.5376	-0.0114	-0.9929	-0.0102
month18	0.0571	0.0082	0.0748	0.0052	0.0803	0.0111
month19	0.3435	0.0133	0.3778	0.0144	0.2915	0.0122
month20	0.2108	0.0075	0.4840	0.0073	-0.1315	0.0076
month21	-0.5773	0.0000	-0.5580	-0.0020	-0.5348	0.0020
month22	-0.4173	0.0157	-0.2626	0.0149	-0.5369	0.0166
month23	-0.4668	0.0184	-0.4863	0.0160	-0.4385	0.0209
month24	-0.3467	0.0099	-0.1900	0.0102	-0.5007	0.0095
month25	0.0985	0.0065	-0.0428	0.0055	0.2650	0.0075
month26	-0.1432	0.0105	-0.1998	0.0099	-0.0297	0.0110
month27	-0.2187	0.0113	-0.2753	0.0100	-0.1581	0.0127
month28	-0.0124	0.0014	-0.2503	0.0005	0.1983	0.0023
month29	0.2626	-0.0026	0.5159	-0.0040	0.0380	-0.0013
month30	0.0750	-0.0056	-0.6091	-0.0061	0.5400	-0.0051
month31	0.6006	-0.0130	0.7536	-0.0136	0.4727	-0.0124
month32	-0.2403	-0.0142	0.0421	-0.0154	-0.4760	-0.0131
month33	-0.2092	0.0095	-0.4207	0.0077	-0.0174	0.0113

month34	-0.1156	0.0363	0.0468	0.0352	-0.2828	0.0375
month35	-0.5026	0.0380	-0.5960	0.0376	-0.3811	0.0384
month36	-0.3344	0.0298	-0.2227	0.0296	-0.4242	0.0300
month37	-0.0387	0.0134	0.3686	0.0123	-0.6047	0.0146
month38	0.0351	0.0061	0.0119	0.0061	0.1033	0.0062
District1	-0.3544	-0.2177	-0.2458	-0.2149	-0.5112	-0.2204
District2	-0.5096	-0.2097	-0.4804	-0.2083	-0.5441	-0.2112
District3	0.3047	-0.2113	0.5023	-0.2088	0.1484	-0.2137
District4	0.3918	-0.2174	0.2477	-0.2156	0.4641	-0.2192
District5	-0.1139	-0.1793	0.0366	-0.1758	-0.2511	-0.1827
District6	-0.0603	-0.0857	-0.0672	-0.0814	-0.0422	-0.0900
District7	-0.0185	-0.1513	0.0342	-0.1479	-0.0494	-0.1548
District8	-1.2824	-0.2219	-1.2668	-0.2199	-1.2299	-0.2238
District9	0.5377	-0.1615	0.4967	-0.1577	0.5982	-0.1653
District10	0.2689	-0.1828	0.2931	-0.1808	0.2465	-0.1848
District11	0.5986	-0.2130	0.2874	-0.2102	0.8852	-0.2158
District12	0.3913	-0.1440	0.4247	-0.1444	0.3592	-0.1435
District13	-0.0510	-0.0781	-0.1031	-0.0783	-0.0033	-0.0779
District14	0.0505	-0.1080	0.1461	-0.1052	-0.0654	-0.1107
InspSysMAESTRO	-0.1228	0.3088	-0.1436	0.3079	-0.0138	0.3096
InspSysMAESTRO,Nu-Tech	-0.1219	-0.0144	-0.0504	-0.0150	-0.0640	-0.0138
InspSysMAESTRO,Religio	0.0269	-0.0106	-0.1947	-0.0126	0.2813	-0.0086
InspSysMAESTRO-SIS	-0.5622	-0.0315	-1.8466	-0.0330	0.1943	-0.0301
InspSysNELS	0.0633	0.0670	-0.0188	0.0656	0.2369	0.0684
InspSysNELS,MAESTRO	0.5052	-0.0236	0.6424	-0.0248	0.4402	-0.0224
InspSysNELS,NTIS,MAEST	0.7756	-0.0325	0.8684	-0.0335	0.8551	-0.0315
InspSysNELS,Nu-Tech	-0.3414	-0.0267	0.1567	-0.0279	-0.7383	-0.0255
InspSysNELS,Nu-Tech,Re	0.6381	-0.0304	0.7337	-0.0311	0.7066	-0.0297
InspSysNELS,Religious	0.3605	-0.0080	0.5837	-0.0108	0.2934	-0.0052
InspSysNELS,SIS	0.2929	-0.0220	0.1642	-0.0227	0.5175	-0.0213
InspSysNELS,SIS,Religi	-0.2293	-0.0296	0.0992	-0.0310	-0.4378	-0.0282
InspSysNu-Ova	-0.8808	-0.0333	-0.3615	-0.0342	-3.0147	-0.0325
InspSysNu-Tech	-0.1878	0.0886	-0.3631	0.0903	0.0876	0.0870
InspSysNu-Tech,Religio	-0.4308	-0.0286	-0.3161	-0.0291	-0.4191	-0.0281
InspSysSIS	-0.0361	0.1452	0.0259	0.1401	0.0137	0.1502
InspSysSIS,MAESTRO	0.3542	0.0011	0.2914	0.0007	0.5088	0.0015
InspSysSIS,MAESTRO,Rel	0.2889	-0.0292	0.2840	-0.0311	0.3791	-0.0273
InspSysSIS,Religious S	-0.3865	-0.0255	-0.4129	-0.0270	-0.2581	-0.0241
InspSysSIS-Nu-Tech	0.0660	-0.0198	-0.0234	-0.0218	0.2237	-0.0178
InspSysSIS-NuOva	-0.8173	-0.0289	-0.9757	-0.0303	-0.5229	-0.0276
Sep_Tox	0.0001	258.0830	0.0000	257.0309	0.0002	259.1351

Contam	0.0005	34.1020	0.0005	33.4667	0.0006	34.7371
AirSac	0.0000	134.3891	0.0000	142.7701	0.0001	126.0088
sum_SP	0.0021	12.9624	0.0024	12.9508	0.0019	12.9740
sum_SNP	0.0461	0.5536	0.0451	0.5580	0.0491	0.5493
sum_U	-0.0032	29.1353	-0.0010	29.0843	-0.0056	29.1864
sum_NC	0.0091	0.7834	0.0025	0.7869	0.0196	0.7798

Appendix Table 7. Prevalence Estimates from the Young Chicken *Salmonella* Model for the Mean, Rehang, and Post-chill Sample Collection Locations

Estimates	unsplit	split1	split2
BX (rehang= mean)	-2.3905	-2.4041	-2.4069
BX (rehang= 1) post-chill	-2.7290	-2.7535	-2.7373
BX (rehang= -1) rehang	0.3376	1.5320	-0.7224
Prevalence (rehang= mean)	0.0839	0.0829	0.0826
Prevalence (rehang= 1) post-chill	0.0613	0.0599	0.0608
Prevalence (rehang= -1) rehang	0.4039	0.4158	0.3892
Prevalence unweighted	0.1231	0.1226	0.1235

Appendix Table 8. Parameter Estimates from the Young Chicken *Campylobacter* Split Datasets

Parameter	B unsplit	mean	B split1	mean	B split2	mean
Intercept	0.3286	1.0000	0.2875	1.0000	0.4175	1.0000
Rehang	-0.6359	-0.0003	-0.6443	0.0259	-0.6463	-0.0265
loglinespeed	1.2788	2.0428	1.2441	2.0428	1.2848	2.0429
logInspectors	-0.9754	1.3214	-0.8820	1.3222	-1.0994	1.3206
lines	0.0497	2.1751	0.0694	2.1799	0.0305	2.1702
Himp	-0.4332	0.1327	-0.4044	0.1330	-0.4538	0.1324
month1	-0.1895	-0.0630	-0.6428	-0.0403	1.5155	-0.0857
month2	-0.0734	-0.0085	-0.0710	0.0021	-0.0911	-0.0192
month3	0.5022	0.0063	0.4724	0.0162	0.5727	-0.0037
month4	0.2178	0.0012	0.1247	0.0088	0.4277	-0.0064
month5	0.2193	0.0075	0.0787	0.0195	0.4805	-0.0046
month6	0.1160	-0.0018	-0.1132	0.0052	0.1816	-0.0088
month7	-0.1053	-0.0032	-0.1489	0.0095	-0.0387	-0.0159
month8	-0.0817	-0.0055	-0.1046	0.0037	-0.0457	-0.0146
month9	0.1315	0.0018	-0.2289	0.0091	-0.2282	-0.0055
month10	-0.3165	0.0026	-0.3073	0.0113	-0.2962	-0.0061
month11	-0.2484	0.0014	-0.2782	0.0107	-0.1985	-0.0079
District1	-0.3553	-0.2318	-0.3006	-0.2315	-0.4227	-0.2321
District2	-0.3201	-0.2353	-0.3690	-0.2339	-0.3255	-0.2367
District3	-0.5514	-0.2315	-0.7509	-0.2306	-0.3496	-0.2324

District4	-0.3275	-0.2351	-0.4915	-0.2339	-0.1427	-0.2364
District5	0.1098	-0.1991	0.1810	-0.1979	0.0378	-0.2004
District6	-0.0589	-0.0820	0.0159	-0.0808	-0.1348	-0.0833
District7	0.2839	-0.1700	0.3628	-0.1677	0.2042	-0.1723
District8	-0.6106	-0.2336	-0.6771	-0.2330	-0.5854	-0.2342
District9	0.4256	-0.2052	0.5492	-0.2025	0.3060	-0.2080
District10	0.1869	-0.2072	0.2304	-0.2059	0.1410	-0.2086
District11	1.5979	-0.2321	1.3490	-0.2309	1.9126	-0.2333
District12	-0.2427	-0.1475	-0.1381	-0.1464	-0.3443	-0.1485
District13	-0.3898	-0.0907	-0.3474	-0.0887	-0.4343	-0.0927
District14	0.3007	-0.0944	0.2965	-0.0936	0.3164	-0.0952
InspSysMAESTRO	-0.8593	0.3385	-0.9787	0.3388	-0.7395	0.3382
InspSysMAESTRO,Nu-Tech	-0.4422	0.0127	-0.6049	0.0128	-0.2462	0.0125
InspSysMAESTRO,Religio	-0.0386	0.0041	0.0216	0.0046	-0.1066	0.0037
InspSysMAESTRO-SIS	-0.5936	-0.0131	-0.5830	-0.0128	-0.5870	-0.0134
InspSysNELS	-0.7700	0.0718	-0.8675	0.0717	-0.6704	0.0720
InspSysNELS,MAESTRO	-0.4104	0.0008	-0.6552	0.0006	-0.1678	0.0009
InspSysNELS,NTIS,MAEST	-1.8641	-0.0168	-1.8537	-0.0165	-1.9102	-0.0171
InspSysNELS,Nu-Tech	10.6210	-0.0177	10.7515	-0.0168	9.9638	-0.0186
InspSysNELS,Nu-Tech,Re	-0.7159	-0.0087	-0.9883	-0.0082	-0.4274	-0.0091
InspSysNELS,Religious	-0.9813	0.0035	-0.8961	0.0040	-1.0827	0.0030
InspSysNELS,SIS	-0.4999	-0.0055	-0.7386	-0.0052	-0.2767	-0.0058
InspSysNELS,SIS,Religi	-0.1027	-0.0128	-0.1361	-0.0128	-0.0791	-0.0128
InspSysNu-Tech	-0.8998	0.1136	-0.9766	0.1134	-0.8265	0.1138
InspSysNu-Tech,Religio	-0.2656	-0.0029	-1.2466	-0.0024	0.7596	-0.0034
InspSysSIS	-0.5426	0.1629	-0.6646	0.1641	-0.4284	0.1616
InspSysSIS,MAESTRO	-0.8898	0.0178	-0.9271	0.0186	-0.8542	0.0171
InspSysSIS,MAESTRO,Rel	0.4083	-0.0134	0.8663	-0.0131	0.2159	-0.0137
InspSysSIS,Religious S	-1.1934	-0.0131	-1.0458	-0.0128	-1.4245	-0.0134
InspSysSIS-Nu-Tech	-0.0369	-0.0069	-0.0588	-0.0067	-0.0235	-0.0070
InspSysSIS-NuOva	-0.1944	-0.0119	1.4957	-0.0119	-2.0137	-0.0119
Sep_Tox	0.0005	295.953	0.0005	297.638	0.0006	294.26
Contam	-0.0003	49.3667	-0.0005	48.8615	-0.0001	49.872
AirSac	-1.00E-05	237.906	-3.00E-05	229.711	1.30E-05	246.10
sum_SP	0.0076	6.5629	0.0118	6.5784	0.0039	6.5474
sum_SNP	0.0198	0.6929	0.0183	0.6879	0.0210	0.6979
sum_U	-0.0014	31.092	-0.0022	31.1031	-0.0006	31.082
sum_NC	-0.0157	1.3634	-0.0078	1.3617	-0.0220	1.3652

Appendix Table 9. Prevalence Estimates from the Young Chicken *Campylobacter* Model for the Mean, Rehang, and Post-chill Sample Collection Locations

Estimates	unsplit	split1	split2
BX (rehang= mean)	1.1615	1.1755	0.9760
BX (rehang= 1) post-chill	0.5254	0.5479	0.3125
BX (rehang= -1) rehang	1.7972	1.8365	1.6052
Prevalence (rehang= mean)	0.7616	0.7641	0.7263
Prevalence (rehang= 1) post-chill	0.6284	0.6336	0.5775
Prevalence (rehang= -1) rehang	0.8578	0.8625	0.8327
Prevalence Unweighted	0.7333	0.7310	0.7356

Appendix Table 10. Parameter Estimates from the Young Turkey *Salmonella* Split Datasets

Parameter	B unsplit	mean	B split1	mean	B split2	mean
Intercept	-13.1301	1.0000	-13.7398	1.0000	-11.0424	1.0000
rehang	-1.7619	-0.6770	-1.7406	-0.1678	-1.7728	0.1678
loglinespeed	7.4946	1.4706	8.1873	1.4706	5.4553	1.4706
logemployees	3.6115	0.9212	3.0640	0.9212	5.0195	0.9212
lines	-2.7200	1.2420	-2.8184	1.2420	-2.5020	1.2420
month14	-0.3209	0.0583	-0.1256	0.0583	-0.7948	0.0583
month15	0.7339	0.0943	0.6582	0.0943	0.7898	0.0943
month16	0.6898	0.1040	0.7230	0.1040	0.6085	0.1040
month17	0.3507	0.0929	0.2723	0.0929	0.4151	0.0929
month18	0.2939	0.0874	0.1584	0.0874	0.4748	0.0874
month19	0.5901	0.0693	0.4681	0.0693	0.6994	0.0693
month20	0.5215	0.0721	0.4142	0.0721	0.5889	0.0721
month21	0.1840	0.0818	0.0628	0.0818	0.2895	0.0818
month22	-1.5164	0.0867	-1.0174	0.0867	-5.0329	0.0867
month23	-0.8771	0.0777	-0.8407	0.0777	-1.0566	0.0777
month24	-0.5709	0.0798	-0.9067	0.0798	-0.3064	0.0798
month25	-0.2184	0.0867	-0.4303	0.0867	-0.0354	0.0867
district1	0.4785	-0.0576	0.7216	-0.0576	0.0289	-0.0576
district2	-0.6647	-0.1290	-0.6636	-0.1290	-0.4711	-0.1290
district3	0.3415	0.0069	0.6031	0.0069	-0.0099	0.0069
district4	0.9143	-0.0596	0.9601	-0.0596	1.1142	-0.0596
district5	0.0481	-0.0673	0.4158	-0.0673	-0.0823	-0.0673
district6	0.3492	-0.0368	0.5643	-0.0368	0.1535	-0.0368
district7	-1.5516	-0.1047	-1.2849	-0.1047	-1.8853	-0.1047
district8	-0.6302	-0.0770	-0.3543	-0.0770	-0.8661	-0.0770

district9	-0.2110	-0.0132	-0.1346	-0.0132	-0.4063	-0.0132
district10	0.8127	-0.0617	0.8419	-0.0617	0.8601	-0.0617
district11	-0.9561	-0.1269	-2.7293	-0.1269	0.6884	-0.1269
district12	1.0358	-0.0673	1.1407	-0.0673	0.7464	-0.0673
InspSysHIMP	-1.6265	0.1179	-1.5988	0.1158	-1.4969	0.1200
InspSysNTIS	0.1801	0.6845	0.1829	0.6803	0.2115	0.6886
InspSysOtherNTIS	0.7410	0.0257	0.8485	0.0236	0.6748	0.0277
sep_tox	0.0015	63.1945	0.0007	63.3731	0.0036	63.0160
contam	0.0023	3.3797	0.0026	3.9619	-0.0791	2.7975
airsac	0.0011	9.9397	0.0015	10.7621	-0.0026	9.1172
synovitis	-0.0067	4.8176	-0.0022	4.8904	-0.0118	4.7448
sum_SP	-0.0344	10.8187	-0.0268	10.8308	-0.0445	10.8065
sum_SNP	0.0444	0.9022	0.0681	0.8988	0.0182	0.9057
sum_U	-0.1027	8.8464	-0.0894	8.8405	-0.1056	8.8523
sum_NC	-0.0548	0.5374	-0.0479	0.5270	-0.0589	0.5479

Appendix Table 11. Prevalence Estimates from the Young Turkey *Salmonella* Model for the Mean, Rehang, and Post-chill Sample Collection Locations

Estimates	unsplit	split1	split2
BX (rehang= mean)	-2.8464	-2.8534	-2.8557
BX (rehang= 1) post-chill	-2.9980	-2.9823	-2.9792
BX (rehang= -1) rehang	-2.0782	-2.2187	-2.2496
Prevalence (rehang= mean)	0.0549	0.0545	0.0544
Prevalence (rehang= 1) post-chill	0.0475	0.0482	0.0484
Prevalence (rehang= -1) rehang	0.1112	0.0981	0.0954
Prevalence Unweighted	0.0729	0.0729	0.0715

Appendix Table 12. Parameter Estimates from the Young Turkey *Campylobacter* Split Datasets

Parameter	B unsplit	mean	B split1	mean	B split2	mean
Intercept	-13.1301	1.0000	-13.7398	1.0000	-11.0424	1.0000
rehang	-1.7619	-0.6770	-1.7406	-0.1678	-1.7728	0.1678
loglinespeed	7.4946	1.4706	8.1873	1.4706	5.4553	1.4706
logemployees	3.6115	0.9212	3.0640	0.9212	5.0195	0.9212
lines	-2.7200	1.2420	-2.8184	1.2420	-2.5020	1.2420
month14	-0.3209	0.0583	-0.1256	0.0583	-0.7948	0.0583
month15	0.7339	0.0943	0.6582	0.0943	0.7898	0.0943
month16	0.6898	0.1040	0.7230	0.1040	0.6085	0.1040
month17	0.3507	0.0929	0.2723	0.0929	0.4151	0.0929
month18	0.2939	0.0874	0.1584	0.0874	0.4748	0.0874
month19	0.5901	0.0693	0.4681	0.0693	0.6994	0.0693
month20	0.5215	0.0721	0.4142	0.0721	0.5889	0.0721

month21	0.1840	0.0818	0.0628	0.0818	0.2895	0.0818
month22	-1.5164	0.0867	-1.0174	0.0867	-5.0329	0.0867
month23	-0.8771	0.0777	-0.8407	0.0777	-1.0566	0.0777
month24	-0.5709	0.0798	-0.9067	0.0798	-0.3064	0.0798
month25	-0.2184	0.0867	-0.4303	0.0867	-0.0354	0.0867
district1	0.4785	-0.0576	0.7216	-0.0576	0.0289	-0.0576
district2	-0.6647	-0.1290	-0.6636	-0.1290	-0.4711	-0.1290
district3	0.3415	0.0069	0.6031	0.0069	-0.0099	0.0069
district4	0.9143	-0.0596	0.9601	-0.0596	1.1142	-0.0596
district5	0.0481	-0.0673	0.4158	-0.0673	-0.0823	-0.0673
district6	0.3492	-0.0368	0.5643	-0.0368	0.1535	-0.0368
district7	-1.5516	-0.1047	-1.2849	-0.1047	-1.8853	-0.1047
district8	-0.6302	-0.0770	-0.3543	-0.0770	-0.8661	-0.0770
district9	-0.2110	-0.0132	-0.1346	-0.0132	-0.4063	-0.0132
district10	0.8127	-0.0617	0.8419	-0.0617	0.8601	-0.0617
district11	-0.9561	-0.1269	-2.7293	-0.1269	0.6884	-0.1269
district12	1.0358	-0.0673	1.1407	-0.0673	0.7464	-0.0673
InspSysHIMP	-1.6265	0.1179	-1.5988	0.1158	-1.4969	0.1200
InspSysNTIS	0.1801	0.6845	0.1829	0.6803	0.2115	0.6886
InspSysOtherNTIS	0.7410	0.0257	0.8485	0.0236	0.6748	0.0277
sep_tox	0.0015	63.1945	0.0007	63.3731	0.0036	63.0160
contam	0.0023	3.3797	0.0026	3.9619	-0.0791	2.7975
airsac	0.0011	9.9397	0.0015	10.7621	-0.0026	9.1172
synovitis	-0.0067	4.8176	-0.0022	4.8904	-0.0118	4.7448
sum_SP	-0.0344	10.8187	-0.0268	10.8308	-0.0445	10.8065
sum_SNP	0.0444	0.9022	0.0681	0.8988	0.0182	0.9057
sum_U	-0.1027	8.8464	-0.0894	8.8405	-0.1056	8.8523
sum_NC	-0.0548	0.5374	-0.0479	0.5270	-0.0589	0.5479

Appendix Table 13. Prevalence Estimates from the Young Turkey *Campylobacter* Model for the Mean, Rehang, and Post-chill Sample Collection Locations

Estimates	unsplit	split1	split2
BX (rehang= mean)	-1.9928	-2.8116	-3.5105
BX (rehang= 1) post-chill	-4.9475	-4.8444	-4.9858
BX (rehang= -1) rehang	-1.4237	-1.3632	-1.4402
Prevalence (rehang= mean)	0.1200	0.0567	0.0290
Prevalence (rehang= 1) post-chill	0.0071	0.0078	0.0068
Prevalence (rehang= -1) rehang	0.1941	0.2037	0.1915
Prevalence Unweighted	0.1189	0.1401	0.0978

Appendix Table 14. Regression Coefficients for Unscheduled Procedures by Inspection Element

	Young Chicken - *Salmonella*				
ISP Element	B	Std Error	p-value	Mean	Std Dev
sum01_U	-0.0020	0.0150	0.8966	0.3741	0.7482
sum03_U	-0.0030	0.0016	0.0500*	13.2204	14.3555
sum04_U	-0.0035	0.0015	0.0237*	12.1161	10.3950
sum05_U	0.0845	0.0159	<.0001*	0.8947	0.6132
sum06_U	-0.0146	0.0053	0.0058*	1.7249	2.6899
sum08_U	0.0059	0.0212	0.7813	0.8051	0.6211
	Young Chicken - *Campylobacter*				
ISP Element	B	Std Error	p-value	Mean	Std Dev
sum01_U	0.0065	0.0205	0.7528	0.3741	0.7482
sum03_U	-0.0264	0.0146	0.0715	13.2204	14.3555
sum04_U	-0.0780	0.0280	0.0053*	12.1161	10.3950
sum05_U	-0.1099	0.0183	<.0001*	0.8947	0.6132
sum06_U	0.0128	0.0063	0.0435*	1.7249	2.6899
sum08_U	0.0043	0.0277	0.8775	0.8051	0.6211
	Young Turkey - *Campylobacter*				
ISP Element	B	Std Error	p-value	Mean	Std Dev
sum01_U	-0.0994	0.1244	0.4242	0.2510	0.6869
sum03_U	-0.1031	0.0492	0.0363*	2.6741	1.7617
sum04_U	-0.0818	0.0860	0.3412	2.8266	1.0534
sum05_U	-0.0559	0.1252	0.6556	0.9917	0.6807
sum06_U	-0.1675	0.0808	0.0381*	1.1390	1.1582
sum08_U	-0.2074	0.2018	0.3040	0.9639	0.3763

Appendix Table 15. Regression Coefficeint for Unscheduled Procedures by ISP Code

	Chicken-*Salmonella*				
ISP Code	B	Std Error	p-value	Mean	Std Dev
sum01B_U	0.0143	0.0468	0.7596	0.0768	0.2763
sum01C_U	0.0022	0.0184	0.9055	0.2886	0.6435
sum01_Uother	-0.2239	0.1081	0.0383*	0.0087	0.1038
sum03B_U	0.0200	0.0561	0.7216	0.0356	0.2071
sum03C_U	-0.1036	0.0294	0.0004*	0.3627	1.2117
sum03J_U	-0.0026	0.0017	0.1133	12.3816	13.8886
sum03_Uother	0.1119	0.0272	<.0001*	0.4405	1.3024
sum04_U	-0.0034	0.0015	0.028*	12.1161	10.3950
sum05_U	0.0799	0.0159	<.0001*	0.8947	0.6132
sum06D01_U	-0.1247	0.0181	<.0001*	0.3250	0.6210

sum06_Uother	-0.0076	0.0055	0.1652	1.4000	2.6579
sum08_U	0.0036	0.0212	0.8644	0.8051	0.6211
	Chicken-*Campylobacter*				
ISP Code	B	Std Error	p-value	Mean	Std Dev
sum01B_U	0.0259	0.0551	0.6383	0.0627	0.2522
sum01C_U	-0.0015	0.0240	0.9501	0.2849	0.6290
sum03B_U	0.1078	0.0459	0.0190*	0.0610	0.3019
sum03C_U	0.0771	0.0402	0.0554	0.3054	0.9130
sum03J_U	-0.0097	0.0020	<.0001*	13.8051	15.3436
sum03_Uother	-0.0940	0.0357	0.0085*	0.3814	1.0212
sum04_U	0.0060	0.0019	0.0020*	11.6642	9.6596
sum05_U	-0.1072	0.0184	<.0001*	0.7620	0.7275
sum06D01_U	0.0488	0.0223	0.0286*	0.3667	0.6456
sum06_Uother	0.0065	0.0066	0.3249	1.8606	2.8507
sum08_U	0.0145	0.0281	0.6066	1.1757	0.5389
	Turkey-*Campylobacter*				
ISP Code	B	Std Error	p-value	Mean	Std Dev
sum01B_U	0.1405	0.3308	0.6709	0.0659	0.2591
sum01C_U	-0.4178	0.2833	0.1403	0.1342	0.3480
sum01_Uother	0.0636	0.3130	0.8390	0.0510	0.3136
sum03B_U	-0.2212	0.4389	0.6143	0.1120	0.3701
sum03C_U	-0.0018	0.4102	0.9965	0.1449	0.4170
sum03J_U	0.2225	0.3607	0.5372	1.0482	0.4321
sum03_Uother	-0.1558	0.3077	0.6127	1.3689	0.9374
sum04_U	-0.1010	0.0905	0.2643	2.8266	1.0534
sum05_U	-0.0678	0.1306	0.6036	0.9917	0.6807

Appendix Table 16. Prevalence Estimates for Models Disaggregated by Unscheduled Procedures

Variable (6)	CS[1]	CC[2]	TS[3]	TC[4]
BX (rehang= mean)	-2.3906	1.1632	-2.8368	-3.1793
BX (rehang= 1) post-chill	-2.7291	0.5257	-2.9746	-4.9373
BX (rehang= -1) rehang	-0.3889	1.8003	-2.1386	-1.4213
Prevalence (rehang= mean)	0.0839	0.7619	0.0554	0.0400
Prevalence (rehang= 1) post-chill	0.0613	0.6285	0.0486	0.0071
Prevalence (rehang= -1) rehang	0.4040	0.8582	0.1054	0.1945
Variable (10-12)	CS	CC		TC
BX (rehang= mean)	-2.3928	1.1645		-3.2059
BX (rehang= 1) post-chill	-2.7317	0.5267		-4.9695
BX (rehang= -1) rehang	-0.3885	1.8019		-1.4423
Prevalence (rehang= mean)	0.0837	0.7622		0.0389
Prevalence (rehang= 1) post-chill	0.0611	0.6287		0.0069
Prevalence (rehang= -1) rehang	0.4041	0.8584		0.1912

1 CS chicken-Salmonella model 2 CC chicken-Campylobacter model
3 TS turkey-Salmonella model 4 TC turkey-Campylobacter model

Appendix Table 17. Number of Establishments in the Four Observed Datasets by SBA Size

Pathogen	Species	L	S	V	total
Salmonella	chicken	133	48	8	189
Campylobacter	chicken	130	45	5	180
Salmonella	turkey	26	26	13	65
Campylobacter	turkey	24	22	12	58
total		313	141	38	492

Appendix Table 18. Number of Establishments Expected to adopt the New Inspection System by SBA Size

Species	switch	L	S	V	total
chicken	170	127	43	0	170
turkey	30	20	10	0	30
subtotal	200	147	53	0	200
other	19	2	14	3	19
total	219	147	72	3	219

Appendix Table 19. Number of Observed Establishments Expected to adopt the New Inspection System by SBA Size

Pathogen	Species	L	S	V	total
Salmonella	chicken	128	50	2	180
Campylobacter	chicken	128	50	2	180
Salmonella	turkey	21	17	1	39
Campylobacter	turkey	21	17	1	39
total		298	134	6	438

Appendix Table 20. Observed Baseline Datasets and Expected to Shift Baseline Datasets Prevalence Estimates

Dataset Prevalence Estimates	Young Chicken			
	Salmonella		*Campylobacter*	
Estimates	observed	expected	observed	expected
BX (rehang= mean)	-2.3905	-2.394	1.1615	1.16579
BX (rehang= 1) post-chill	-2.729	-2.7289	0.5254	0.53519
BX (rehang= -1) rehang	0.3376	-0.4119	1.7972	1.79619
Prevalence (rehang= mean)	0.0839	0.08363	0.7616	0.76238
Prevalence (rehang= 1) post-chill	0.0613	0.06129	0.6284	0.63069
Prevalence (rehang= -1) rehang	0.4039	0.39846	0.8578	0.85768

Prevalence Unweighted	0.1231		0.7333	
Dataset Prevalence Estimates	Young Turkey			
	Salmonella		*Campylobacter*	
Estimates	observed	expected	observed	expected
BX (rehang= mean)	-2.8464	-2.8625	-1.9928	-2.0155
BX (rehang= 1) post-chill	-2.998	-3.0221	-4.9475	-5.108
BX (rehang= -1) rehang	-2.0782	-2.0233	-1.4237	-1.369
Prevalence (rehang= mean)	0.0549	0.05404	0.1200	0.11759
Prevalence (rehang= 1) post-chill	0.0475	0.04644	0.0071	0.00601
Prevalence (rehang= -1) rehang	0.1112	0.11678	0.1941	0.20278
Prevalence Unweighted	0.0729		0.1189	